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MEETINGS OF THE SOCIETY

NEW YORK MEETING, JANUARY 9

The members of the Society resident in New York will hold a meeting January 9 to consider the work of the Society for the current year and their own share in it. Never in the history of the Society have its activities been extended in so broad and useful a way as at the present time. At this meeting members of the several Standing Committees and of the Committee on Meetings in New York will give informal talks upon the plans under way.

The meeting will be opened by the chairman of the New York Committee, with a statement as to the subject of the meeting and what it is desired to accomplish. He will be followed by President Humphreys who will talk upon the recent activities of the Council. Charles E. Lucke will then speak upon the work of the Committee on Meetings; F. A. Waldron on some problems before the New York Committee, on which opportunity for discussion will be given; R. M. Dixon on the finances of the Society; G. J. Foran on the problem of membership; F. R. Low on publications; Leonard Waldo on the Society's library; and Edward Van Winkle on the business of the House Committee. All these remarks will be brief and will cover the ground as fully as possible in a limited space of time.

The meeting will constitute a general get-together of the New York members to consider future plans with relation to their part in the activities of the Society, and a large attendance is anticipated on so important an occasion.

BOSTON MEETING, JANUARY 15

The annual dinner of the members of the Society and of the Boston Society of Civil Engineers and the Boston Section of the American Institute of Electrical Engineers will be given on January 15, 1912, at the Hotel Somerset. The Boston Society of Civil Engineers will have charge of the meeting and committees are actively at work on the arrangements. Addresses will be made by officials of the three organizations represented.

BOSTON MEETING, DECEMBER 20

A meeting of the Society with the Boston Society of Civil Engineers and the Boston Section of the American Institute of Electrical Engineers was held in Boston on December 20, the electrical engineers presiding.

The paper of the evening, Electric Propulsion of Ships, was read by the author, W. L. R. Emmett, engineer of the lighting department of the General Electric Company, Schenectady, N. Y. Mr. Emmett, who is eminently qualified to discuss this subject and who served many years in the Navy, gave a detailed description of the various methods of propulsion in use in marine work at the present time, and showed where the system which he proposed, viz., turbines, generators and motors, was by far the most economical from the standpoints of saving in fuel, in engine room space, weight of machinery, etc. He stated that for a number of years past the General Electric Company had been trying to get the United States Navy Department to give his system of electric propulsion a trial on one of their large ships, and that the contract had at last been awarded to equip one of the large colliers now building with their apparatus. Mr. Emmett expects to have the apparatus which will be used on the ship set up in the factory and tested out under conditions as nearly similar as possible to those which will be met with in service, and believes he will be able to show how much more economical its operation is than that of any other equipment. He further outlined the details for equipping some of the large battleships and ocean liners with electric propulsion, and explained in detail the gearing system for use on ships and the difficulties which would be encountered with it. His remarks were illustrated by lantern slides.

The paper was discussed by I. N. Hollis of Harvard University and C. H. Peabody of the Massachusetts Institute of Technology.

CURRENT AFFAIRS OF THE SOCIETY

To emphasize the national character of the Society and to indicate the Society's interest in its individual members, the Secretary will make a tour during the month of January which will include most of the cities where meetings of the members are held and as many as possible of the student branches located in the various universities and institutes. The Secretary will represent on this trip the officers of the Society and will tell the members of the work in hand and contemplated.

The plans include the following points and events: January 3, meeting of the Buffalo members, to be addressed by the Secretary and by John Calder, the latter speaking on Economic Management of Industrial Establishments; January 4, visit to the Ohio State University Student Branch; January 5, visits to student branches at the University of Cincinnati, and the University of Kentucky at Lexington, Ky.; January 6, meeting of the members in St. Louis and visit to Washington University, St. Louis; January 7, visit to the University of Missouri, Columbia, Mo.; January 8, visit to the University of Kansas, Lawrence, Kansas; January 9, visit to University of Nebraska, Lincoln, Neb.; January 10, meeting of Denver members; January 16, visit to Leland Stanford Jr. University, Palo Alto, and the University of California, Berkeley, Cal.

On January 15 the Secretary will attend the meeting of the representatives of national engineering organizations, called in San Francisco, Cal., to consider plans for an Engineering Congress which is proposed for 1915, in connection with the Panama-Pacific Exposition to be held in that year to commemorate the opening of the Panama Canal.

On the return trip, the Secretary will stop at the following points: Iowa State College, Ames, Ia.; University of Iowa, Iowa City, Ia.; St. Paul; University of Wisconsin, Madison, Wis.; Chicago; Purdue University, Lafayette, Ind.; Cleveland; Pittsburgh; and Pennsylvania State College, State College, Pa.

Calvin W. Rice, *Secretary*

ANNUAL MEETING

The thirty-second Annual Meeting of the Society, one of the largest and most enthusiastic of its history, was held at the Society Headquarters in New York, December 5–8, 1911. The feature of this year's meeting was the extraordinarily large average attendance, the total registration exceeding 1200, with 687 members and 545 guests in attendance at its various gatherings. The Committee on Meetings had prepared a program of unusual interest, comprising contributions from three of the new sub-committees recently appointed to investigate special subjects, and all the sessions were well attended and brought out discussion of value. On Wednesday evening the address by Dr. Robert S. Woodward, of the Carnegie Institution of Washington, was much enjoyed by all in attendance, and appreciation was expressed of Dr. Woodward's courtesy in consenting to address the membership. Interesting and varied technical excursions and the splendid entertainment features arranged by the Committee on Meetings in New York, assisted by the Ladies' Reception Committee, formed a social background to the meeting and contributed to the spirit of fellowship which prevailed.

OPENING SESSION, TUESDAY EVENING

Following the successful arrangement of previous years, the President's Reception was held in the rooms of the Society on Tuesday evening. This was preceded by a meeting in the auditorium where E. D. Meier, retiring President, delivered the presidential address, entitled, The Engineer in the Future, in which he briefly sketched the engineering achievements of the past and predicted great opportunities and responsibilities for the future.

A portrait of Colonel Meier was then presented to the Society by Walter M. McFarland, who expressed his regret at the absence of Mr. C. J. H. Woodbury, who had been so instrumental in arranging for the gift and the presentation. He reminded the membership of President Meier's professional and military record, and said that the presentation of this portrait was the completion of the tribute paid to Colonel Meier at the Pittsburgh meeting last Spring, when

an engrossed set of resolutions was offered to him on the occasion of his seventieth birthday. He expressed the hope in conclusion that Colonel Meier might for many years continue active in the Society and that he might have increased happiness and prosperity.

Colonel Meier responded with a few brief words of thanks and called on Theodore Stebbins, Chairman of the Tellers of Election of Officers, to make the report of the election. The following result of the ballots cast was given: President: Alex. C. Humphreys; Vice-Presidents: Wm. F. Durand, Ira N. Hollis, Thos. B. Stearns; Managers: Chas. J. Davidson, Henry Hess, George A. Orrok; Treasurer: Wm. H. Wiley. George Westinghouse, Geo. W. Melville and Fred. W. Taylor, Past-Presidents of the Society, were appointed to escort Dr. Humphreys to the platform, and an introductory speech was made by Colonel Meier outlining Dr. Humphreys' career and describing him as a typical engineer, a man not afraid of work and who loved his work. He spoke also of his international reputation as the foremost specialist in the gas industry and of the honor he had received at the hands of Stevens Institute and other universities and colleges. He expressed the belief of all, in conclusion, that Dr. Humphreys might safely be intrusted with the affairs of the Society which he would be sure to handle in a way of which the Society might be proud.

Dr. Humphreys in his reply spoke of his appreciation of the honor conferred upon him and of his recognition of the responsibility which it entailed, and said he liked to think of the Society as organized within the walls of the first college devoted distinctly to the study of engineering, and that its first President was then an instructor in that institution.

The audience then proceeded to the rooms of the Society, which had been appropriately decorated for the occasion, where the membership met the new officers and renewed acquaintance with one another. Music was rendered during the evening and a collation was served. George J. Foran acted as Chairman of the sub-committee in charge of the reception.

WEDNESDAY MORNING, BUSINESS MEETING

The first professional session of the convention opened on Wednesday morning in the auditorium with the annual business meeting. Vice-President Baker presided in the absence of the President.

The report of the Tellers of Election to Membership was read

by the Secretary, announcing the admission of 187 new members and the promotion of 17.

The Annual Report of the Council was read by the Secretary, and during the reading of the resolutions upon the death of Charles Wallace Hunt, incorporated in it, the entire audience rose and paid a silent tribute to his memory. In connection with the report, the Secretary spoke of the necessity of growth in a Society with activities covering so great a scope, and said he was glad to state that the resources of the Society were now nearly three-quarters of a million dollars, the only indebtedness being the certificates held by the membership, which would be redeemed as rapidly as possible.

The Chairman happily termed the meeting that of the stockholders in a business corporation, the Council being the Board of Directors, and reminded them that this occasion presented an opportunity for criticism. The fact that the members now had no mortgage on their home was due, he said, in no small part to Charles Wallace Hunt.

The following amendment to C 21 of the Constitution, proposed by the New York Committee on Meetings at the Spring Meeting in Pittsburgh, was then considered:

> Members of all grades residing in New York and vicinity and represented by the Committee on Meetings in New York City, should have the privilege and authority by majority vote of such membership to increase their annual dues by the sum of $3, such increase to be applied to financing such entertainment features of the Annual Meetings in New York City and its own local meetings as their Committee on Meetings in New York City may elect.

Jesse M. Smith, Chairman of the Committee on Constitution and By-Laws, proposed the following amendment to this amendment:

> The expense of all meetings of the Society, and any group or section thereof, shall be arranged in accordance with such By-Laws and Rules as the Council may from time to time adopt, provided, however, that nothing in this section shall be construed to authorize the Council to make any increase of annual dues of members in any grade.

The motion was seconded by George M. Brill, and a discussion ensued in which a large number participated. Walter Rautenstrauch, Chairman of the New York Committee on Meetings, said that his committee believed the amendment proposed at the Pittsburgh meeting represented the wishes of the membership resident in New York, since a recent canvass indicated a strong desire to substitute an increase of dues for the yearly assessment plan. A

number then expressed themselves in favor of the amendment as proposed by Mr. Smith, and it was suggested that the Society should make an assessment from its funds so that the burden might not fall so heavily upon any one section of the membership. This, Dr. Humphreys pointed out, would not be possible in view of the proposed enlargement of the Society's operations for which its present income would be insufficient. The majority seemed to agree that the entertainment features should not be omitted, and several spoke of the profit to be gained from mutual acquaintance among men of affairs, who talked more freely of their work on social occasions than they could be persuaded to do at professional meetings.

The amendment proposed by Jesse M. Smith was finally adopted as a substitute for that proposed by the New York Committee, and it was voted to send this amendment out to the entire membership for letter ballot.

WEDNESDAY MORNING SESSION—PROFESSIONAL PAPERS

Three papers were discussed following the business meeting at the Wednesday morning session. The first of these, The Turret Equatorial Telescope, by James Hartness of Springfield, Vt., dealt with a new type of astronomical observatory designed to protect the observer from cold. A revolving turret for the polar axis of the instrument is used for this purpose, making the instrument and building integral. The paper was discussed by W. R. Warner, Ambrose Swasey, William Kent, Henry Hess and F. R. Hutton.

Sterling H. Bunnell of New York then presented his paper on Expense Burden: Its Nature and Incidence, which dealt with the correct distribution of burden items over the various producing units of the factory, thus stabilizing the cost of product against the effect of temporary changes in the expense schedule, while providing a definite standard of running expense as a measure of the efficiency of the supervising department. This was discussed by H. F. Stimpson, Harrington Emerson and B. A. Franklin.

Standard Cross-Sections by H. deB. Parsons of New York was next presented by the author, and pointed out the advantage of a uniform method for cross-sectioning drawings so as to indicate graphically the materials. This was discussed by F. DeR. Furman.

WEDNESDAY AFTERNOON—PROFESSIONAL SESSION

Following a luncheon served on the fifth floor of the Engineering Societies Building, a second professional session was held in the

auditorium, commencing at 2 o'clock, at which a paper by D. S. Jacobus, of New York, on Tests of Large Boilers at the Detroit Edison Company, was presented by H. O. Pond of New York, in the absence of the author. This paper describes tests made on two boilers at the plant of the Detroit Edison Company, one being fitted with Roney Stokers and the other with Taylor stokers. The paper was discussed by R. H. Rice, R. D. DeWolf, H. O. Pond, W. D. Ennis, D. C. Johnson, H. deB. Parsons, H. H. Esselstyn, E. G. Bailey, Wm. Kent, R. C. Carpenter, J. C. Parker, E. J. Billings, W. F. M. Goss, E. D. Dreyfus, Mr. Thomas and H. G. Stott.

James E. Howard of Washington, D. C., presented his paper on Strain Measurements of Some Steam Boilers under Hydrostatic Pressures, giving hydrostatic tests made upon two horizontal tubular boilers which had been in service for a period of 27 years, and showing the strains occurring at the locations where measurements were taken. This was discussed by Mr. Allen.

A paper contributed by the sub-committee on Machine Shop Practice, Herringbone Gears, with Special Reference to the Wuest System, was presented by its author, Percy C. Day of Milwaukee. The Wuest System, founded and developed in England to a high degree of perfection within recent years, has made possible the production of this type of gears with the requisite speed and accuracy. The paper was discussed by F. E. Rogers, F. DeR. Furman, L. D. Burlingame and W. C. Brown.

SIMULTANEOUS SESSION, CEMENT MANUFACTURE

A simultaneous session was also held on Wednesday afternoon arranged by the sub-committee on Cement Manufacture. Six papers were presented, illustrated by lantern slides. These included, Confirmation of the Advantages of Electricity to the Cement Manufacturer, by J. B. Porter of Philadelphia, giving a résumé of information on the subject obtained from various cement manufacturers; and Electrical Power in Cement Plants, by F. H. Lewis, Birmingham, Ala., which offered further facts along the same line. Both papers were discussed by Mr. Pratt, Mr. Wylie, H. J. K. Freyn, H. Struckmann, H. S. Spackman and Mr. Dudley.

Two papers on prevention of accidents in cement plants were then presented, Protection of Laborers from Accidents and Injury to Health in Cement Plants, by Otto Schott of New York, and Methods and Appliances for Prevention of Accidents in Cement

Plants, by J. G. Bergquist of Buffington, Ind. There was no discussion.

A paper was then presented by the author, Holger Struckmann, on Depreciation and Obsolesence in Portland Cement Plants, which was discussed by H. S. Spackman and Mr. Higgins. Dr. Schott presented a second paper on The Dust Problem in Portland Cement Plants, which offered various methods of solution of this very important problem. This was discussed at length by Mr. Mason, H. S. Spackman, J. G. Bergquist, J. B. Porter, W. B. Ruggles and Mr. Brown.

WEDNESDAY AFTERNOON RECEPTION

On Wednesday afternoon the Ladies' Reception Committee, Mrs. Jesse M. Smith, Chairman, entertained the membership and their guests in the Society rooms, at an informal reception, in which a large number participated. Music was rendered throughout the afternoon and refreshments were served. Although on similar occasions in previous years the hospitality of the ladies had been greatly appreciated, this year's reception was considered the most successful of all.

WEDNESDAY EVENING

On Wednesday evening Dr. Robert S. Woodward, President of the Carnegie Institution of Washington, D. C., gave a fascinating address on Geo-Dynamics. Dr. Woodward said that more is known about the earth than about any other body, and spoke of its shape, its area of 196,940,000 sq. miles, its volume of 259,880,000,000 cu. miles, and the four parts into which it is divided, the atmosphere, hydrosphere, lithosphere and centrosphere. The total mass of the earth is 6600 by 10^{18} tons and it is covered with crust to a depth of 10 miles, which is represented by 23 by 10^{18}. Of this crust 50 per cent is oxygen, 25 silicon, 7 aluminum, and 5 iron. The crust of the earth rests on its nucleus as if the whole mass were fluid, and the internal pressures are therefore substantially hydrostatic. Its density increases from about 2.75 at the surface to about 11 at the center, and its pressure from zero to about 3,000,000 atmospheres. The amount of internal heat of the earth escaping each year is sufficient to melt 800 cubic miles of ice. A million years seems to be the smallest convenient unit of time which can be used in reckoning the age of the earth. The kinetic energy of translation of the earth equals 63,200 by 10^{30} foot-pounds; and of the rotation of the earth, 157 by 10^{27} foot-pounds. The first of these is 400,000 times

the second and is more than will be developed at Niagara at the present rate of about 5,000,000 horsepower in a million million years. The effects of the earth as a timekeeper are shown in secular cooling, meteoric dust, tidal friction, the shifting of surface load, and Maxwell's meteorite. Dr. Woodward also spoke of the origin of the earth, outlining the nebular hypothesis, the theory of meteoric dust and the argument from the moon.

The lecture was well attended and brought out many expressions of commendation and interest.

THURSDAY MORNING, PROFESSIONAL SESSION

At the professional session called to order in the auditorium on Thursday morning four papers were presented. The first, The Core-Room: Its Equipment and Management, was read by the author, Henry M. Lane of Cleveland, Ohio, and dealt with the subject of foundry cores and core-room practice, particularly core-room location and arrangement, core sands and binders, the selection and compounding of core materials, core ovens and drying, core pasting, handling and storage, and core machines and core-room rigging. It was discussed by A. E. Outerbridge, T. D. West, A. N. Kelley, B. D. Fuller, H. A. Becker and E. H. Mumford.

Tests of a Sand-Blasting Machine, by Wm. T. Magruder of Columbus, Ohio, was presented by the author, and gave the records and results of quantitative tests of such a machine under the actual conditions of commercial practice. The paper was discussed by F. C. Brooksbank, J. M. Betton, W. S. Giele, A. G. Warren and S. C. Smith.

A paper by Amasa Trowbridge of Hartford, Conn., on Die Castings, was then presented. The paper summarizes briefly the state of the art of making small castings in steel molds and outlines the principles for this process of casting and of hand and automatic casting machines.

Variable-Speed Power Transmission, by George H. Barrus of Boston and Charles M. Manly of New York, was read by Mr. Barrus, in which was described a mechanism called the Manly Drive and a series of efficiency tests made on it. The mechanism is fundamentally a hydraulic device and the fluid used is ordinary machine oil. After the presentation of the paper Mr. Barrus gave a practical demonstration of variable-speed power transmission by means of a Manly Drive equipment erected on the platform.

SIMULTANEOUS SESSION, GAS POWER SECTION

A session of the Gas Power Section was also held on Thursday morning. R. H. Fernald, Chairman of the Section, presided and read the annual address on The Gas Power Field for 1911, in which he outlined graphically the rapid progress which is being made. Announcement of the newly elected officers was then made by the Tellers of Election, as follows: Chairman, H. J. Freyn; Secretary, George A. Orrok. Mr. Freyn was escorted to the chair by F. R. Low and made a brief speech of thanks.

The meeting then proceeded to the consideration of professional topics, and H. R. Setz of Warren, Pa., presented his paper on Oil Engines, in which he described the Diesel engine and its modifications, commonly known as constant-pressure engines, and explained the principles underlying the various processes of fuel injection.

A paper by Forrest M. Towl of New York, on the Test of an 85-H.P. Oil Engine, was presented by the Secretary. This described a test of a De La Vergne engine, FH type, operating an oil pump, and one of the same engine under the same conditions but with the load applied by a prony brake instead of a pump. The papers were discussed together by C. E. Sargent, A. J. Frith, L. K. Doelling, L. B. Lent, Wm. Sangster, James Craig, L. P. Breckenridge and H. J. K. Freyn.

W. D. Ennis of Brooklyn, N. Y., then presented his paper on Design Constants for Small Gasolene Engines, in which an attempt to develop a more general expression than the common rating formulae which consider piston displacement as the only variable and which shall include the effect of piston speed variations, was described.

E. D. Dreyfus of East Pittsburgh then presented a paper on A 1000-Kw. Natural Gas Engine: Tests, Construction and Working Costs, prepared by himself and V. J. Hultquist of New York, in which was described the testing of a large gas engine in commercial service, with the economies realized in both construction and operation. The paper was discussed by W. D. Ennis, I. E. Moultrop and G. A. Orrok.

The session concluded with a vote of thanks to the officers and committees for their faithful and untiring work and successful endeavors of the year which had elapsed.

THURSDAY AFTERNOON, INSPECTION OF THE OLYMPIC

About 500 members and guests visited the S.S. Olympic on the

invitation of the White Star Line on Thursday afternoon. As this was the first trip made by the giant vessel since her accident some months ago, she was an object of especial interest. Through the courtesy of the ship's officers and guides detailed by them, the members had an excellent view of the splendid appointments of the vessel and of the many conveniences for comfortable traveling which have been incorporated into this literal floating palace. Although the Olympic was delayed in starting on her trip and did not dock at the Chelsea pier until Thursday morning, the guests were made welcome most adequately and offered every possible assistance in their inspection of the boat.

THURSDAY EVENING, REUNION

On Thursday evening the grand ballroom at the Hotel Astor was the scene of a brilliant gathering at the annual reunion of the Society, given by the New York members to the visiting membership and their guests. Dancing commenced at nine o'clock and was largely participated in, although a number occupied the boxes with which the ballroom abounds. The New York Committee, assisted by a sub-committee, F. A. Scheffler, Chairman, had arranged novel features for the occasion, such as lighting effects during the dances, and expressions of admiration at the result of these ingenious innovations were heard on every hand. Refreshments were served throughout the evening and a royal welcome extended to all.

FRIDAY MORNING, PROFESSIONAL SESSION

The concluding professional session of the convention was held on Friday morning in the auditorium, and was exceptionally well attended. A paper contributed by the sub-committee on Textiles entitled The Development of the Textile Industries of the United States, by Frank W. Reynolds of Boston, was presented by Albert L. Pearson, of the same city, and gave a general statement of present conditions, covering the field in a very adequate and illuminating way. The great development in these industries has led to the concentration of engineering skill upon construction, power, machinery, and general plant arrangement, so that the general efficiency of modern mills is high, but there are yet many unsolved problems which seem to depend largely upon the mechanical engineer. The paper was discussed by E. D. Dreyfus, C. T. Main, G. R. Stetson, Mr. Eccles, G. H. Perkins, C. F. Scott, A. J. Herschmann, J. A. Pratt, W. L. Lyall, G. M. Brill, Dwight Seabury, Calvin W. Rice, G. H. Perkins, and Mr. Willister.

Two papers on air conditioning were then presented by the author, Willis H. Carrier of Buffalo, N. Y., Rational Psychrometric Formulae: Their Relations to the Problems of Meteorology and of Air Conditioning; and Air-Conditioning Apparatus. In the latter paper F. L. Busey of Buffalo acted as joint author. Both papers, which supplemented one another, dealt with the artificial regulation of atmospheric moisture, and gave a theoretical discussion of the subject, developing formulae for the solution of problems. They were discussed by R. C. Carpenter, L. S. Marks, H. E. Longwell, O. P. Hood, R. C. H. Heck, J. I. Lyle, F. R. Still, Thos. M. Gunn and H. M. Prevost-Murphy.

A paper on Some Experiences with the Pitot Tube on High and Low Air Velocities, was then presented by the author, Frank H. Kneeland of Gary, W. Va., which related to the use of the Pitot tube for the measurement of flow of large volumes of air and tests made at the plant of the United States Coal and Coke Company at Gary. The paper was discussed by G. D. Gebhardt, R. C. Carpenter and W. H. Carrier.

At the conclusion of the session, the following resolutions of thanks were offered and unanimously adopted:

Whereas the members and guests of The American Society of Mechanical Engineers at the Annual Meeting, December 1911, have again been accorded opportunities for participating in professional sessions of unusual merit and in the entertainment provided by the New York membership,

Be It Resolved that on behalf of the visiting members and guests the Secretary extend the thanks of the Society to the Committee on Meetings for the excellence of this convention; to the Committee on Meetings in New York and the Ladies' Committee for the pleasure afforded by the various entertainment features; to Dr. R. S. Woodward for his instructive and illuminating lecture; to the officials of the White Star Line and the officers of the S.S. Olympic for the privilege of visiting this latest and largest transatlantic liner; to Thomas A. Edison, Honorary Member of the Society; and to the following firms and public works, from whom cordial invitations were received to visit their plants: Bush Terminal Company, Brooklyn, N. Y.; Brooklyn Navy Yard; E. W. Bliss Company, Brooklyn, N. Y.; J. H. Horton Ice Cream Company, New York; Ward Bread Company, Brooklyn, N. Y.; and the Hotel Astor, New York.

EXCURSIONS

Through the efforts of the Excursion Committee, Walter Rautenstrauch, Chairman, a number of interesting and enjoyable excursions to technical points were made on Friday afternoon.

About 150 members and guests were entertained at the Edison Laboratory, Orange, N. J., where they were personally welcomed by Mr. Edison, who is an Honorary Member of the Society. The party

made the trip in a special car and dinner was served in the laboratory immediately upon their arrival. Millar Reese Hutchinson, one of Mr. Edison's engineers, gave a lecture on the construction and performance of the Edison storage battery, and presented to Professor Rautenstrauch, who conducted the party, the "key" of the laboratory, consisting of a copper wire in a test tube which Mr. Edison said was the key to many of his achievements. The visitors were conducted through the various parts of the works and were shown two inventions, publicly displayed for the first time, the improved phonograph placed within a cement case which gives better acoustic properties, and the kinetograph, a combination of moving pictures and phonograph. Mr. Edison also predicted the extensive use of reinforced concrete in the making of furniture, and showed his new home moving-picture outfit, which without the lighting device is no larger than an ordinary camera and can be carried in the pocket of the operator. The films used are so small that a picture on one of them is scarcely discernible by the naked eye and the process of their manufacture is so delicate that a speck of dust would ruin a picture. Moving pictures of the party entering the laboratory were developed during the visit and displayed to the guests before their departure. The film was presented to them as a memento of the occasion.

Some of the membership made a visit to the plant of the Bush Terminal Company in Brooklyn on Friday afternoon, and viewed the exceptional facilities provided for handling shipments, in addition to the provision made for their manufacture and storage. These comprise seven docks about 1400 feet long; special one-story warehouses for storing cotton and other fibrous materials; a series of six-story warehouses for storing miscellaneous materials, either in bond or free storage; a system of handling bulky freight over long distances, consisting of an electric drive truck, used to draw three or four loaded trailers; model fireproof lofts, about 100 acres in area, each building provided with a side track from a terminal railroad; and a well-arranged freight yard, having about 12 storage tracks with two diagonal series of switches or ladders reaching each individual track so that any car can be picked out of its place in the yard with the least amount of switching. All of the warehouses and loft buildings are provided with the sprinkler system and the lofts have steam heat and electric light and power.

The Brooklyn Navy Yard was also visited by a party of about fifty members and guests, under the guidance of George B. Preston,

and were shown the various points of interest by Lieutenants A. A. Baker and A. L. Parsons of the civil engineering department. These included the power plant which generates all the electricity used, both for lighting and power, and which has recently been remodelled and extended, the reciprocating engines formerly in use being replaced by steam turbines; the engineering department machine shop where the main engines and steam auxiliaries of the battleship New York were in process of construction, and the foundry and boiler shops, full and interesting explanations of the work in progress being given in every case. After the inspection the party was conducted by Midshipman H. K. Lewis over the battleship Delaware, which was in dock, being overhauled, and had a very complete view of the vessel, including its method of operation and the sighting and firing of the 13 in. rifles. Full opportunity was given to the visitors to examine at their leisure the main engines, boilers and auxiliary steam equipment.

A smaller party visited the E. W. Bliss Company in Brooklyn, where they were conducted through the works by Mr. Bailey. The inspection included the engineering and drafting department, the assembling of the smaller sizes of punch presses, single and double action, the can-making machinery department, with its various automatic machines which eliminate handling as much as possible, the large press department where some double draw presses were in different stages of completion, and the die department with its wide range of work. Only the torpedo department where the Government work is done was omitted, as visitors are not permitted to see it. The trip proved most interesting and was enjoyed by all.

Godfrey M. S. Tait conducted a party through the J. M. Horton Ice Cream Company's Plant, New York, probably the largest suction gas plant in the country and the largest installation of gas producers ever allowed inside a factory building within the city limits. The gas producers are two in number and are each rated at 350 h.p., operating continuously 24 hours a day. Especial care has been taken to make this plant a model one, eliminating fire risks as much as possible. The party were very pleasantly entertained by the company.

About 30 members and guests enjoyed an interesting trip to the plant of the Ward Bread Company, recently established in Brooklyn, where modern methods for cleanliness and sanitation have been installed. The equipment consists of a complete system of bucket elevators and screw conveyors for transporting the flour from the

storage bins in the basement to the weighing machines on the top floor. This is mixed in dough-mixing drums with water drawn into storage tanks from supply lines furnishing it of the desired temperature. The mixers are operated by individual motor drives, with automatic control for starting and stopping. When ready the dough is placed in tubs suspended on an overhead rail system and allowed to rise. It is molded and kneeded by machines of ingenious design, connected by a series of belt conveyors for carrying the prepared dough preparatory to placing in pans for baking. On the second floor there are three long rows of coal-fired ovens, fitted with steam jets for supplying moisture and equipped with a device for maintaining the desired temperature. The baked loaves of bread are carried by conveyors, passing in front of each row of ovens; and are delivered into the packing and shipping room on the first floor through open spiral chutes. It is then put into wagons from the shipping room which is entirely surrounded by an enclosed platform. Robert P. Schoenijahn conducted the party and a guide was detailed by the company to show the visitors about.

Throughout the convention the American Museum of Safety, located on the sixth floor of the Engineering Societies Building, was open to inspection by the membership. Models and photographs of safety devices to protect the lives of workmen and the public were on view and were explained by an attendant.

A Bureau of Information was conducted in the foyer of the building and data concerning time tables, points of amusement, hotels, etc., put at the disposal of the members. Walter Rautenstrauch acted as Chairman of the Bureau.

ENTERTAINMENT OF LADIES

The Ladies' Reception Committee, composed of ladies resident in and about New York, Mrs. Jesse M. Smith, Chairman, as usual contributed much to the pleasure of the convention. In addition to the reception given on Wednesday afternoon, in which both members and guests participated, trips were arranged to various points of interest to the visiting ladies. A Ladies' Guides Committee, Mrs. Charles R. Wight, Chairman, was in charge of this feature. On Wednesday morning a large number of ladies visited the Public Library where they were shown about by a guide detailed for the purpose by the library officials, and had a very complete view of the fine new building opened to the public in the spring of 1911. Through the courtesy of the John Wanamaker management, Thurs-

day morning was very delightfully spent in visiting this large department store under the care of a special guide. A short concert was given in the auditorium and various other of the store's many facilities evoked to add to the pleasure of the party. On Friday morning an inspection was made of the Herter Looms, founded by Albert Herter, A. N. A., where some remarkable work in tapestry and similar decorative work is being done under Mr. Herter's personal supervision. Workmen have been brought from abroad and every effort is being made to produce domestic work which will vie with that being done in Europe. The visit proved most instructive and interesting.

In addition to these excursions, the ladies participated in the trip to the Olympic and to the Edison Laboratory and Ward Bread Company on Thursday and Friday afternoons. One of the guides held herself in readiness to accompany ladies to the two large museums which New York boasts, and others were prepared to show those who desired through the shops and other points of interest to visitors. Many ladies availed themselves of the opportunity to meet one another in the Ladies' Headquarters established in the rooms of the Society, and many expressed their appreciation of the Committee's hospitality.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The Student Branch of the Armour Institute of Technology held a meeting December 6, at which L. H. Philleo and J. D. Bradford presented a paper, Some Phases of Rotary Gas Engines. A proposed rotary gas engine designed by the authors was described in detail. The construction and operation of the engine were fully explained with the aid of numerous finished drawings of the details and assembled parts. In the discussion which followed, the advantages and disadvantages of rotary engines, as compared with those of the piston type, were taken up. The chief mechanical obstacles pointed out for an engine of this type were excessive friction of the moving parts and packing troubles.

COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch, November 23, Prof. F. R. Hutton lectured on the Prevention of Accidents.

CORNELL UNIVERSITY

The subject of Soldering was discussed before a meeting of the Cornell University Student Branch, November 1, by Professors Hess, Barnard, Wolff, Franck, Curtiss and Yoakum, and Mr. Matthews. On November 17, Professor Carpenter discussed the papers, recently published in The Journal, by W. H. Carrier, D. S. Jacobus and F. H. Kneeland.

On December 8, M. M. Upson delivered an address on Concrete Piles, Their Manufacture and Uses.

LEHIGH UNIVERSITY

At a meeting of the Lehigh University Student Branch in October, an interesting and instructive discussion took place on the subject of Aviation. A paper by James Bailey, The Practicability of Aeroplanes, divided the subject into four parts, safety, reliability, economy and utility and said that airships at present are neither safe nor reliable and are too expensive for commerce, but of great utility in military work. In his paper on Aerial Motors, H. B. Tinges gave a brief history of the development of aeronautical motors from the

time of Sir Hiram Maxim's flights in 1894. A third paper on the subject of Aero-Dynamics was contributed by Nevin H. Guth.

Morris L. Cooke spoke on Scientific Management at a second meeting of the branch in October.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Mechanical Engineering Society of the Massachusetts Institute of Technology held a meeting November 23, when Irving E. Moultrop gave a talk on Power Plant Design, with special emphasis on the boiler room. He also explained in detail the arrangements at the L Street station of the Boston Edison Company.

OHIO STATE UNIVERSITY

Mr. S. Swarr told of his experiences with large waterwheels and pumping machinery while in the employ of the Platt Iron Works, Dayton, Ohio, at a meeting of the Ohio State University Student Branch, November 20. An abstract of Frederick W. Taylor's paper on the Principles of Scientific Management, made by A. I. Brown, was also presented. A discussion followed in which Professor Hitchcock and Messrs. Belt and W. J. Assel took part.

RENSSELAER POLYTECHNIC INSTITUTE

The Rensselaer Polytechnic Institute has elected the following officers for the new term: A. M. Greene, Jr., Honorary Chairman; W. D. Small, President, and A. E. Moore, Secretary.

STATE UNIVERSITY OF KENTUCKY

Alonzo G. Kenyon delivered a lecture at the November meeting of the State University of Kentucky Student Branch on Fuel Economy and the Method of Presenting these Ideas to Locomotive Engineers and Firemen. The lecture included the illustration of the chemistry of combustion and the properties of coal and firing by laboratory experiments and blackboard diagrams.

STEVENS INSTITUTE OF TECHNOLOGY

At a meeting of the Stevens Engineering Society, November 9, James Hartness dealt with the psychology of invention in his lecture, Some Non-Technical Phases of Machine Design. On November 16, A. W. MacNabb addressed the society, his subject being The Manufacture of the Edison Mazda Lamp. Mr. Callender of the Studebaker Corporation spoke on the Manufacture and Testing of Automobiles at the meeting of the society, November 23.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch held a meeting November 15, at which Walter Tangeman presented a paper on The Knight-Silent Engine.

UNIVERSITY OF ILLINOIS

The Student Branch of the University of Illinois held a meeting December 8, and J. M. Weff of the Mine Rescue Station gave a talk on the Draeger Oxygen Helmet, and five miners gave a demonstration of first aid to the injured.

UNIVERSITY OF KANSAS

At the November 9 meeting of the University of Kansas Student Branch Lawrence L. Brown read a paper on The Indiana Steel Company's Plant at Gary, Ind. The program also included reports on the following magazines: Horseless Age, Mr. Coggins; The Journal of The American Society of Mechanical Engineers, Mr. Tangeman; and Die Zeitschrift des Vereines deutscher Ingenieure, Mr. Van Houten.

At a meeting held December 7 the program was as follows: The Western Electric Company's Plant at Chicago, J. D. Howard; The Reinforced Concrete Arch across the Tiber River at Rome, L. Angevine; A New Material for Aeroplane Motors, Mr. Fairchild; The Task and Bonus System of Management, Mr. Wentling.

The student branch held its annual meeting December 14, at which the following papers were read: Drilling Gas Wells, Wm. M. Welch; Care of Gas Wells, H. R. Davis; Internal-Combustion Engines and Their Performance in Service, G. E. Hines; The Action of Reciprocating Pump Valves, Prof. C. I. Corp; Shop Management, B. W. Benedict; Relation of Technical School Engineers to the Practical Profession; Do Schools Pay? Louis Bendit. Prof. W. A. Whitaker gave a complete history of steel and iron manufacture from the Mesabi Range ore to the finished product, and illustrated his talk with lantern slides.

UNIVERSITY OF MISSOURI

At a meeting of the University of Missouri Student Branch, November 20, a paper on the Gas Power Plant Equipment by Ralph George and P. A. Tanner was read. On December 4 a lecture was delivered on the National-Acme Machine Company's multiple spindle screw-cutting machine, by O. L. Henn, demonstrator for the company.

WASHINGTON UNIVERSITY

Mr. Rossi presented a paper on Oil Fuel for Steam Boilers at a meeting of Washington University Student Branch, November 23. The uses, advantages, costs, etc., were fully discussed. A second paper was read by Mr. Berger on Advice to Engineering Graduates.

YALE UNIVERSITY

The Yale University Student Branch held a meeting on December 3, and Prof. Charles H. Benjamin, Dean of the Engineering Schools of Purdue University, gave an illustrated lecture on The Cost of Power. Charts were shown on which the prices of various manufacturers were compared.

MEETINGS OF THE COUNCIL

DECEMBER 5, 1911

A meeting of the Council was held on December 5, 1911, E. D. Meier, President, presiding. There were present: Chas. Whiting Baker, George M. Brill, Alex. C. Humphreys, Henry G. Stott, Irving E. Moultrop, James Hartness, H. G. Reist, Henry L. Gantt, Stanley G. Flagg, Jr., F. R. Hutton, F. W. Taylor, Jesse M. Smith and Calvin W. Rice, Secretary. Regrets were received from W. F. M. Goss.

Voted: That the reports of the Standing Committees be accepted and published in The Journal and Transactions.

Voted: That the Annual Report of the Council be accepted.

Voted: To amend the action of the Council by changing the words "student members" to "student affiliates" and the words "Sister National Engineering Societies" to "the American Society of Civil Engineers, the American Institute of Electrical Engineers and the American Institute of Mining Engineers."

The President reported with respect to an International Engineering Congress proposed for January 1915, that he had had a conference with the President-elect of the American Society of Civil Engineers, also Alfred P. Boller, Vice-President of the American Society of Civil Engineers, with Charles Kirchhoff, President of the American Institute of Mining Engineers, and with Gano Dunn, President of the American Institute of Electrical Engineers, and that they had expressed themselves in favor of such a congress, to be held in San Francisco in 1915.

The Secretary read a letter from T. W. Ransom, Secretary of the San Francisco Committee on Meetings, advising the Society of a meeting of the members resident in and about San Francisco at which a report was received from the chairman of the committee on an International Congress, and suggesting that the Society appoint three delegates to attend a preliminary meeting January 15, 1912, for the purpose of formulating plans, one of such delegates to be an executive officer of the Society.

Voted: That it was the sense of the Council that the Society favor preliminary consideration of the matter. The Secretary was instructed to represent the Society at the meeting called for the formulation of plans, January 15, 1912, with two other members of the Society, to be chosen by the President from the membership in and about San Francisco.

The Secretary was also instructed to see that all meeting places, halls, etc., be provided for free in the arrangements made by the Exposition.

Voted: That the action of the Council accepting the resignation from membership of E. M. Blake be rescinded.

The Secretary reported the following deaths: H. W. Bulkley, T. B. Davis, J. J. Ferrier, H. S. Morrison, Thos. F. Slater.

The New York Committee on Meetings presented nominations from the membership.

Henry G. Stott, appointed Honorary Vice-President to represent the Society at the hearings of the National Waterways Commission, made an informal report to the effect that he had appeared before the Commission as the representative of the Society and the American Institute of Electrical Engineers, and in behalf of the Electrical Engineers presented a brief. The Commission devoted a day and a half to the consideration of the presentation made by the representatives of the engineering societies, and at the conclusion publicly thanked them in recognition of the splendid coöperation rendered.

F. G. Tallman, a former member of the Council, was invited to present to the Council a plan covering a testimonial to Prof. John E. Sweet on his eightieth birthday.

Voted: That Ambrose Swasey, Past-President, be appointed chairman of a committee, with power to add to the Committee, to honor Professor Sweet on the occasion of his eightieth birthday, and that the personnel of the committee include members who attended the organization meetings of the Society from among Professor Sweet's boys.

The Committee appointed includes Ambrose Swasey, Chairman, Robert W. Hunt, Wm. Kent, E. D. Leavitt, C. B. Richards, F. G. Tallman, Worcester R. Warner and Wm. H. Wiley.

Voted: To extend the thanks of the Council to Past-President F. W. Taylor, Vice-Presidents C. W. Baker, A. C. Humphreys, W. F. M. Goss, and Managers H. L. Gantt, I. E. Moultrop and W. J. Sando, for their assistance and advice, and to record this expression of regret at the expiration of their term of office.

Voted: That the thanks of the Council be extended to the American Institute of Electrical Engineers for their courtesy in offering the use of the director's room for the meeting of the Council.

Voted: That the thanks of the Council be also conveyed to the American Institute of Mining Engineers, and to the National Electric Light Association for their kind offer of the use of the rooms of their respective societies during the Annual Meeting.

On motion adjourned to Friday, December 8.

DECEMBER 8, 1911

The Council met on Friday, December 8, at 2.30 p.m., and was called to order by E. D. Meier. Jesse M. Smith, Past-President, was appointed to introduce President-elect Alex. C. Humphreys, George M. Brill, Vice-President, to introduce Vice-President Ira N. Hollis, and James Hartness and H. G. Reist to introduce Managers Henry Hess and George A. Orrok.

James Hartness was appointed temporary Secretary and recorded the following minutes.

Voted: That Calvin W. Rice be reappointed Secretary of the Society on the same terms and conditions as last year.

Voted: That F. R. Hutton be reappointed Honorary Secretary on the same terms and conditions as last year.

At this point the Secretary, Calvin W. Rice, assumed his position and recorded the following minutes.

Voted: That Fred J. Miller be reappointed Trustee of the United Engineering Society to serve for a term of three years.

Voted: That F. R. Hutton be reappointed representative of the Society on the John Fritz Medal Board, to serve four years.

Voted: That the Council appoint an Executive Committee to consist of the President and five other members of the Council; that these five members be selected by letter ballot of the members of the Council; that the Secretary be authorized to send a blank ballot to each member of the Council, with a copy of this resolution and be

authorized to receive and count the votes; that the ballots close at 12 o'clock noon on Thursday, December 28, 1911; that the five persons receiving the largest number of votes be declared elected and so notified by the Secretary.

Voted: That for the purpose of contemplated coöperation with engineering societies, it is suggested that the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, and The American Society of Mechanical Engineers appoint a Conference Committee, to consist of two members from each of these four national engineering societies the Conference Committee to hold informal meetings whenever anything may come up that seems of sufficient importance to receive the attention of all the societies, such Committee is to be entirely informal and without legislative power; the representatives of each society to refer matters back for authoritative action, when agreed in committee to be of sufficient importance.

Voted: That if in the opinion of the Conference Committee it is desirable to increase the number of societies represented in this Committee, such opinion be referred back for approval of the governing boards of the societies named in this resolution.

Voted: That the President appoint the representatives of this Society on such Conference Committee.

Voted: To extend to the Committee on Meetings the thanks and congratulations of the Council for all its work in connection with the Annual Meeting.

Understanding that the members have reported in favor of reappointment of the Committee that served last year as a Committee on Meetings in New York, it was

Voted: To approve such Committee, to consist of F. H. Colvin, Walter Rautenstrauch, Edw. Van Winkle, R. V. Wright, F. A. Waldron.

Resolved: That a vote of thanks be extended to the Committee on Meetings in New York for the admirable way in which they carried out the part of the Annual Meeting of which they were in charge.

Voted: That the Committee on Constitution and By-Laws be requested to consider and report to the Council tentative forms of By-Laws to cover the topics referred to in the proposed amendment to the Constitution as discussed and presented at the Annual Meeting just adjourned.

Voted: To approve the action of the Chairman of the Committee

on Constitution and By-Laws at the Wednesday morning session of the Annual Meeting, in changing the words "provided for" to "arranged" as given in the directions of the Council at its meeting of November 20, 1911, and that the minutes of such meeting be so amended.

Voted: To approve the minutes, as amended, of the meeting of the Council, December 5.

Voted: That it is the sense of the Council that regular meetings of Council be held each month, October to May inclusive, at a definite date and hour to be determined later.

On motion meeting adjourned subject to call of the Chair.

THE NEWLY ELECTED OFFICERS FOR 1912

ALEXANDER CROMBIE HUMPHREYS

President Am. Soc. M. E.

Alexander Crombie Humphreys, second president of Stevens Institute of Technology, was born in Edinburgh, Scotland, March 30, 1851. He came to this country at the age of eight and was educated in his father's private school, Boston, Mass. When fourteen years old he passed a preliminary test examination for the United States Naval Academy, but was disqualified on account of his youth. He then entered a Boston insurance office. In 1866 he removed to New York, where he secured employment with the New York Guaranty & Indemnity Company, and in a few years was made receiving teller and assistant bookeeper. In 1872 he became secretary-treasurer, and shortly afterwards superintendent of the Bayonne & Greenville Gas Light Company. For years he had spent much of his spare time working with tools, and he now came in touch with mechanical undertakings as secretary of the building committee of his company. Upon the completion of the plant he was offered the position of secretary and treasurer. Three years later he recognized his need of a technical course at Stevens Institute, and presented himself at recitations and lectures two mornings of each week, doing the prescribed work of the institute at home. During the next four years he kept up with his class, attended to his business duties and supported his wife and two children. In 1881 the president and the faculty of the institute passed a formal resolution congratulating him upon his success under these exceptional conditions. Shortly after his graduation he accepted the office of chief engineer of the Pintsch Lighting Company, for which he built many oil-gas works, conducted experimental work on a large scale, and perfected an organization for carrying on the business. In January 1885, he became superintendent of construction of the United Gas Improvement Company of Philadelphia, and within a few months was its general superintendent and chief engineer. Under a uniform system of management and control developed by him, many properties were operated from Philadelphia. Early in 1892,

in association with Arthur G. Glasgow, he established the London firm of Humphreys & Glasgow, consulting gas engineers, which was successful from the start. This firm designed and constructed the carbureted water gas plant. Other works constructed by Humphreys & Glasgow are now in operation in all parts of the world except North America. Here Mr. Humphreys built many plants as chief engineer of the United Gas Improvement Company. Upon his resignation from the United Gas Improvement Company, two years later, he formed the New York firm of Humphreys & Glasgow, which has been equally prominent in the American field. The specialty of gas engineering presents technical difficulties that few people appreciate, but since entering the field of consultant practice Mr. Humphreys has achieved a reputation far beyond the confines of this branch. When the presidency of Stevens Institute was rendered vacant by the death of Henry Morton, the faculty unanimously petitioned the Board of Trustees to elect Mr. Humphreys, and this action was seconded by many of the alumni individually, who urged his appointment as a man of broad sympathies, an able administrator, and a thorough man of affairs. He was elected June 5, 1902. As president of this great school of practical knowledge he is doing more good than can be readily measured; his outspoken criticisms of technical education, as viewed in some quarters, have already caused a profound conviction of the need of more thoroughness and less display. The University of Pennsylvania has since conferred upon Mr. Humphreys the honorary degree of Sc.D., and the honorary degree of LL.D. has been conferred upon him by Columbia University, New York University and Princeton University.

In 1907 Mr. Humphreys succeeded Bayard Dod as president of the Board of Trustees of Stevens Institute. He is now president of the Buffalo Gas Company. He is a member of the American Institute of Mining Engineers, of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the Institution of Civil Engineers, the British Association for the Advancement of Science, and the American Association for the Advancement of Science; past-president of the American Gas Light Association and of the American Gas Institute; president of the Engineers' Club of New York, the Robert Burns Society, New York, the Canadian Society, New York; a member of the National Society for the Promotion of Industrial Education, of the National Society for the Promotion of Engineering Education, and of the Union League, Century, Lawyers' and Chemists' Clubs of New York; vice-president of St. Andrew's Society,

New York; a member of the University Club, Philadelphia, and many other societies working in public interest; a member of the Chamber of Commerce, New York, and president of Humphreys & Miller, Inc., New York, successors to Humphreys & Glasgow.

VICE-PRESIDENTS

WILLIAM FREDERICK DURAND

William Frederick Durand was born in Beacon Falls, Conn., March 5, 1859, and lived as a boy on a New England farm in Derby, Conn. He was educated in district and high schools, and in 1876 entered the United States Naval Academy in the then recently organized engineering course. He was graduated in 1880 and remained in the naval service as cadet and assistant engineer until 1887. From 1883 to 1885, under the practice then prevailing, he was detailed as instructor in engineering subjects in Lafayette College, Easton, Pa. In 1887 he resigned from the naval service to accept an appointment as professor of mechanical engineering in the State Agricultural College of Michigan, leaving there in 1891 to take the professorship of marine engineering in the newly organized School of Marine Engineering and Naval Architecture in Sibley College, Cornell University, under the general charge of the late Prof. R. H. Thurston. In 1904 he resigned this position and was appointed professor of mechanical engineering in the Leland Stanford Jr. University, which position he still holds.

His later services in the navy were in connection with the design, construction and sea trials of the earliest steel ships of the so-called "New Navy," begun in 1883. His work at Cornell University was largely in the marine field, and he is the author of numerous papers and articles dealing with the problems of marine construction. During this period he also published two books, Resistance and Propulsion of Ships, and Practical Marine Engineering. Since taking up his work in California his professional connections, aside from teaching, have lain largely in the fields of steam and hydraulic power plant engineering, on which he has written numerous articles and papers.

Immediately after the earthquake of 1906, which wrecked in greater or less degree most of the buildings of the university, Professor Durand was partially relieved of his teaching duties and served for about two years and a half as a member of a commission of engineers composed of three members of the engineering faculty,

charged with the executive direction of the work of restoring and rebuilding such of the buildings as were required for immediate purposes.

He has since December 1909, served as a member of a consulting board of engineers for the power bureau of the Los Angeles aqueduct, and has taken an active part in the preparation of plans for the development of hydroelectric power in connection with that enterprise.

IRA NELSON HOLLIS

Ira Nelson Hollis, professor of engineering at Harvard University, was born in Mooresville, Ind., March 7, 1856, and was educated in the public schools of Louisville, Ky. He was appointed cadet engineer at the Naval Academy in 1874 and was graduated in 1878. He was commissioned assistant engineer in the Navy in 1880, passed assistant engineer in 1888, and resigned in 1893, having been appointed to his present position at Harvard. During the fifteen years after graduation from the Naval Academy, he served in various positions connected with the design, inspection and operation of marine machinery, and was chief engineer of two ships.

Professor Hollis has published articles on naval, educational and engineering subjects, and is a member of the following societies: American Academy of Arts and Sciences, United States Naval Engineers, American Society of Naval Architects and Marine Engineers, Boston Society of Civil Engineers, Society for the Promotion of Engineering Education, and Massachusetts Military Historical Association.

THOMAS B. STEARNS

Thomas B. Stearns was born October 3, 1859, in Brooklyn, N. Y., and was educated in the public schools of that city, and at the Brooklyn Collegiate and Polytechnic Institute. He received his engineering training at the Columbia School of Mines, from which he was graduated in 1881, with the degree of E.M. After a number of years spent in examining mines in the western part of the United States and in Mexico, and in studying the milling and smelting processes, ore treatment, and the machinery used in ore handling, he opened an office in Denver in 1885 as a consulting and contracting engineer. The following year he formed a partnership, known as Stearns, Roger & Company, which was merged in 1881 into the Stearns-Roger Manufacturing Company, of which Mr. Stearns is now president.

Mr. Stearns has designed, supervised or constructed a number of important installations, notably central station power and lighting plants, and mills for the chlorination of ores in different centers, and has been largely instrumental in developing the chlorination process as it is now applied, devising new machinery and methods of application for roasting and for chlorination. He has specialized in the treatment of ores of the precious metals, and has built and applied various devices for the mining of minerals, for air compressor and drilling work, hoisting, sorting and handling on the surface, and for concentrating, cyaniding, smelting and milling ores. Since the growth of the beet sugar industry in the West he has studied the refining process and built sugar machinery. The sugar house at Garden City, Kansas, was built by him as well as designed with his assistance.

Mr. Stearns is a member of the American Institute of Mining Engineers, the Colorado Scientific Society, and the American Association for the Advancement of Science, a past-president of the Denver Club and of the University Club of Denver, and a member of the Denver Athletic Club, the Denver Country Club, the University Club of New York and the Automobile Club of America. He is president of the Gilpin County Light, Heat & Power Company, the Arkansas Valley Electric Company, the Brush Light & Power Company, the Hinsdale Power & Development Company, director in the Grand Junction & River Valley Railway Company, and vice-president of the Mountain Electric Company and the Columbia National Life Insurance Company.

MANAGERS

CHARLES JACKSON DAVIDSON

Charles Jackson Davidson was born in Lanesboro, Minn., on July 6, 1867, and received his education in the public schools. At the age of eighteen he apprenticed himself to Hubbard & Gere, machinists and steam-fitters, in Sioux City, Ia., and during his three years of service gained practical experience in engineering. In 1888 he entered the employ of the R. D. Fowler Packing Company at Sioux City, taking charge of the boiler room. After several years he was promoted to the position of chief engineer and continued in this capacity until 1893, when he resigned to take up similar work with the Sioux City Traction Company. Six years later he removed

to Milwaukee to become chief engineer of power plants for The Milwaukee Electric Railway and Street Company, having charge of drafting room and power plant design and superintending the lighting of city and suburban railways and steam heating. During this time Mr. Davidson also acted as consulting engineer for the Union Electric Light and Power Company of St. Louis.

A few months ago Mr. Davidson opened an office of his own in Chicago, under the firm name of Woodmansee, Davidson & Sessions, having resigned his work with the Milwaukee Electric Railway and Street Company in order to do so, and is now engaged in private practice.

HENRY HESS

Henry Hess was born January 10, 1863, at Darmstadt, Germany, and was educated in the German-American Institute, New York City, and at a German high school. Mr. Hess preferred technical pursuits to his father's profession of sculpture and worked in various machine shops to gain the necessary training, being successively journeyman, foreman, superintendent, draftsman and designer. By changing frequently into as diverse lines as possible he covered a wide field, out of which he gradually decided upon machine tool design as his specialty. A five year stay in connection with the building and operation of the German Niles Tool Works Company near Berlin, first as consulting engineer and later as managing director, were productive of familiarity with European machine building conditions. He returned to the United States after having acquired the American ball-bearing patents of the German Small Arms and Manufacturing Company, and became the pioneer of modern ball-bearing development in this country.

Mr. Hess has contributed articles on technical subjects at various times to the American Machinist, Machinery, the Engineering Magazine, etc., and to various professional organizations. He is a past-president of the Society of Automobile Engineers, a president of the Engineers Club of Philadelphia, and a member of the American Electro-Chemical Society of Great Britain, the German Institute of Automobile Engineers, Verein deutscher Ingenieure, Schiffbautechnische Gessellschaft, and Verein fur Eisenbahnkunde. He is president of the Hess-Bright Manufacturing Company and of the Hess Steel Castings Company. During the St. Louis Exposition he served as a member of the jury.

GEORGE A. ORROK

George A. Orrok was born in Dorchester, Mass., on July 3, 1867, and received his education at the Mather School in that city and at the School of Mechanic Arts. He entered the Massachusetts Institute of Technology in 1885, but was obliged to give up his college course in his junior year on account of serious eye trouble. He spent some time investigating mining property in the South and in surveying in Wisconsin, and from 1888 to 1892 engaged in teaching in Bridgewater, West Springfield and Easthampton, Mass., at the Ogden Military Academy in Ogden, Utah., and the Agricultural College at Logan, Utah. In 1892 he entered the employ of F. S. Pearson as draftsman and was engaged in the design of the West End Street Railway, the Dominion Coal Company, the Metropolitan Light Railway Company, the Brooklyn Heights Railway Company, etc.

In 1898 he was employed by the New York Edison Company as draftsman, becoming chief of the department in the same year, and mechanical engineer in 1906, which position he still holds. Mr. Orrok is also assistant engineer to Thomas E. Murray, consulting engineer, and in this capacity has had charge of the design and construction of power houses for a number of railroads and electric lighting companies, including the large hydroelectric development at Chattanooga, Tenn.

He is a member of the American Society of Civil Engineers, the American Institute of Mining Engineers, the Society of Naval Architects and Marine Engineers, a past-president of the Brooklyn Engineers Club, and a member of the Technology Club of New York.

ANNUAL REPORTS OF STANDING COMMITTEES

REPORT OF THE HOUSE COMMITTEE

The decorating and furnishings, completed last year, have proven so adequate and satisfactory that the House Committee refrains from recommending any considerable additional expenditure at present. Summer coverings for furniture, inner curtains and some minor furnishings should be provided for in future appropriations. An authorization, as yet unexpended, covers the work now in progress of securing and hanging the portraits of the Honorary Members.

In this connection, the Committee wishes to acknowledge its appreciation of the painstaking work which the Sub-Committee Chairman, Mr. Van Winkle, has done during the past year for the Society, such work including the collection of the pictures of Past-Presidents and Honorary Members, and a valuable index of important Society relics.

It is the earnest hope of the Committee that the improvements effected will encourage the greater use of the rooms and facilities of the Society by its members.

Respectfully submitted,

F. BLOSSOM, *Chairman*
B. V. SWENSON
E. VAN WINKLE
H. R. COBLEIGH
S. D. COLLETT

House Committee.

REPORT OF THE LIBRARY COMMITTEE

As the library work has developed at the monthly meetings of your Committee, a sense of its responsibility, not only to the Society but to the entire body of practicing engineers, has steadily increased. In no engineering center are so many great patent litigations originated and conducted as in New York, and not only are the records of most recent engineering progress constantly required, but also the history of the art up to the present moment.

The libraries of the Bar Association and of the Academy of Medicine are examples of what has been achieved by other professions.

Your Committee has carefully considered means for the establishment of an organization for library government, and of principles of selection of technical literature, which will develop the present library with symmetry along the lines of engineering science, with stated policies regarding the value of its accessions, in order to secure for it the position among technical libraries which only years of intelligently fostered growth make possible. Your Committee has especially encouraged the use of the library by members of the many organizations having headquarters in the Engineering Societies Building, and these have signified their desire to coöperate in its upbuilding.

Your Committee is gratified at the completion of the handsome gallery in the present main library room, in accordance with the plans of the Joint Library Conference Committee made at the time of the erection of the present building, but delayed by want of funds. By means of this gallery about 10,000 more volumes are made available in the main library reading room.

In connection with the library committees of the two other founder societies, your Committee heartily concurs in the appointment of William Parker Cutter, B. S. Cornell, to the important office of chief librarian. Mr. Cutter has attained distinction as librarian of Forbes Library at Northampton, Mass., and our library has already shown marked improvement under his intelligent administration.

The following library statistics are furnished by the librarian:

October 1, 1910, to September 30, 1911

Accessions	
Purchase	147
Gifts and exchanges	421
Total	568
Cards added to catalogue	12,158
Volumes bound	228
Cost	$252.24 (Average cost $1.10+)
Attendance	
Day	8,021
Night	2,947
Total	10,968

The library has for the past year put its facilities still more within reach of the membership living at a distance through the further development of technical searches. Lists of references have been compiled by request upon the following subjects, among many which might be named: steel belts; combustion of coal dust; efficiency tests of pumps for water works; ball and roller bearings; making of brass tubes; care of belting; size of drums for wire rope; design of hooks

for cranes; automatic stops; fire hose pressure; high-speed tools; drying lumber in kilns; permanent molds; manufacture and properties of phosphor bronze; comparative value of various methods of power transmission; engineering standards and specifications; smoke abatement; composition and heat treatment of steel; steam meters; high pressure turbo-compressors; tap drills for various metals; manufacture of seamless steel tubes; shop costs. In some instances typewritten copies of articles have been furnished as well.

This is an especially valuable side of the work being done by the library and ought to appeal to all members who lack the time or opportunity to visit it to make such searches for themselves. Unless the work is extensive no charge is made and the cost of copying, translation or other service is gaged by the time required, and is slight in proportion to its value. Members are invited to make use of the library in this way.

A bookplate has been adopted by the Committee and will be placed in those books owned by the Society. It bears the seal of the Society above an open volume and also the words, "Ex libris American Society of Mechanical Engineers."

The introduction card which is now issued annually by the Society has been made to combine the features of the member's card for the library, which it was formerly necessary to issue separately on application of a member desiring to consult the files. The new card also has printed on its back the names of societies with whom library privileges are exchanged.

There is under consideration by the Publication Committee a more complete cross-referencing of the entire set of Transactions of the Society, which will add materially to the facilities for consulting papers and subjects treated in Transactions.

There has been received by gift from Professor Unwin, Honorary Member of the Society, the proposals for the first Niagara Falls Power Plant, also a large number of books which have been regularly announced in the successive issues of The Journal under Accessions to the Library. Your Committee also wishes to acknowledge with thanks the receipt of a number of pamphlets, a list of which is now on file in the Secretary's office.

Respectfully submitted,

L. Waldo, *Chairman*
W. M. McFarland
C. L. Clarke
A. Noble
E. G. Spilsbury

Library Committee

REPORT OF THE COMMITTEE ON MEETINGS

During the year, 24 local meetings have been held in addition to the Annual Meeting in New York and the Spring Meeting at Pittsburgh. Of this number 7 were held in New York and Boston, 3 in St. Louis and San Francisco, 3 in Philadelphia, and 1 in New Haven. It is expected to hold meetings in all of these cities during the coming year.

A meeting was also held in May with the Providence Society of Mechanical Engineers, on the new basis of affiliation adopted at the December 1910 meeting of the Council. In accordance with this basis of affiliation, any engineering society which is by its constitution, by-laws and practice in accord with the traditions and aims of the Society, may join with the Society in holding coöperative meetings, the affiliated society maintaining its own independence but having the privilege of reduced subscription rates to the Society's publications and of any printing reductions which the Society may secure. Similar meetings with the Providence society and probably with other organizations will be held from time to time.

Recognizing the necessities of the situation and that, in the holding of meetings by the members in the several parts of the United States, it is impracticable always to have papers formally prepared and forwarded to the central Committee on Meetings for scrutiny before presentation, and furthermore, that such a plan imposes great burdens on the central Committee, the Council has relieved the Committee on Meetings of the necessity of reviewing any papers except those to be presented at the general meetings of the Society, so that the Committee thus resumes its original functions of supervision of the Annual and Semi-Annual Meetings only. This has resulted in a greater sense of responsibility on the part of the Committees on Meetings in the several cities and also a feeling of greater freedom.

The Committee on Meetings has inaugurated, with the hearty approval of the Council, the development of sub-committees for the several branches of engineering. It will be the policy of the Committee to secure through these sub-committees an annual report on the state of the art, thus rounding out the field of activity of the Society, these reports being accompanied by special papers where possible, to be presented at the general meetings of the Society. The members of the Society have been asked, through circulars recently issued, to assist the Committee in this plan by making suggestions of experts

who shall be invited to compose these committees without regard to relationship with the Society.

Three committees have already been formed and are doing excellent work. One upon Cement Manufacture held a most successful session at the Spring Meeting at Pittsburgh and has plans under way for another meeting. Two other committees, one on the Manufacture of Textiles and another on Machine Shop Practice, have arranged for a session at the Annual Meeting.

Respectfully submitted,

L. R. POMEROY, *Chairman*
C. E. LUCKE
H. DEB. PARSONS
W. E. HALL
C. J. H. WOODBURY

Committee on Meetings

REPORT OF THE COMMITTEE ON MEMBERSHIP

During the fiscal year, October 1, 1910 to September 30, 1911, the Committee on Membership has held five meetings, at which a total of 401 applications for membership have been considered with the following results:

Withdrawn for various causes	7
Deferred indefinitely	6
Recommended for membership	368

Of the 368 names recommended for ballot, 327 were new candidates and 41 were candidates for promotion. The candidates recommended were voted for on two ballots submitted to the membership as follows:

Spring Ballot	161
Fall Ballot	205

The names of candidates elected to membership during the year appear in the Annual Report of the Council.

Respectfully submitted,

FRANCIS H. STILLMAN, *Chairman*
GEORGE J. FORAN
HOSEA WEBSTER
THEO. STEBBINS
WM. H. BOEHM

Committee on Membership

REPORT OF THE PUBLICATION COMMITTEE

The Committee has proceeded during the current year on the lines laid down in the report as submitted to the Council at the beginning of the year. Volume 32 of Transactions recently issued contains in addition to the proceedings of the usual meetings a report of the meeting in England. To have published in addition all of the matter presented at the meetings of the year, would have necessitated the issuing of a two-volume edition of Transactions, for which there were not sufficient funds. Instead, a single volume of 1500 pages was published and 16 papers with discussions upon them were omitted.

As outlined in the last annual report, the efforts of the Committee have for several years past been in the direction of making The Journal self-supporting, and although the Committee did not state that this result would be accomplished this year, it did so hope and it now has the satisfaction to report that it has been accomplished as shown in the sub-joined table:

RECEIPTS

	1907–1908	1908–1909	1909–1910	1910–1911
Advertising	......	$12,000	$24.000	$31,000

EXPENSES

Journal Text	$8400	$13,100	$18,500	$16,000
Journal Advertising	....	7,000	11,800	15,000
	$8400	$20,100	$30,300	$31,000

During the past year The Journal has been self-supporting.

It is proposed to develop the condensed catalogue feature of the advertising section, as this form of advertising is believed to be of greater practical value than ordinary display advertisements and entirely in keeping with the character of The Journal. The plan is to make these pages as valuable as possible by incorporating engineering data and it is anticipated that a sufficient number of firms will become interested so that various classes of mechanical equipment will be fully represented in succeeding issues of The Journal.

The Committee has had in mind for a long time the plan of incorporating in the reading pages of The Journal a review of articles appearing in foreign periodicals to be published in the form of a topical index, supplemented by abstracts of some of the more

important ones, the object being to place before members of the Society, although in condensed form, records of advances in engineering throughout the world not covered by our Transactions. The Committee has felt that until The Journal was self-supporting it could not recommend to the Council that it should branch out into new lines made necessary by the employment of a technical reviewer, but it feels now that it is in a position to make this recommendation which will still further add to the value of The Journal and which ought to increase its circulation among non-members, tending gradually to draw them into membership. Such a technical reviewer would be in a position to furnish translations of articles in foreign periodicals for the membership of the Society.

Through action by the Council the subscription price of The Journal has been reduced, making the price to the public 35 cents a copy or $3 a year, and to members 25 cents a copy or $2 a year, to be included in the dues as heretofore. This will make possible a wider distribution of the papers and discussions given at the meetings of the Society, thus adding to its prestige and benefiting the profession as a whole.

Last year the Committee brought to the attention of the Council, the need of indexing the Transactions of the Society from their beginning. It was understood from the Chairman of the Library Committee that certain indexing of other Transactions was contemplated and the Publication Committee has waited to learn what the work would be in order that a recommendation might be made. The Publication Committee desires to bring again to the attention of the Council the great need for a complete index to the volumes of Transactions.

Respectfully submitted,

H. F. J. Porter, *Chairman*
F. R. Low
G. I. Rockwood
G. M. Basford
C. I. Earll

Publication Committee

REPORT OF THE PUBLIC RELATIONS COMMITTEE

One of the most important subjects which has interested the Society and engineers generally, is the bill proposed before the legislature of one of the States, pertaining to the licensing of engineers. The Committee reported to the Council its opinion that it was impractical and inadvisable to pass any laws to license the profession of engineering and the Council in accepting this report instructed

the Committee to coöperate with any other engineering society or with any individual engineers in opposing such laws.

E. D. Meier, President, and Calvin W. Rice, Secretary, attended a meeting of engineers on February 16, 1911, to consider the subject of laws for licensing engineers. Members of the American Society of Civil Engineers, the American Institute of Electrical Engineers, and the American Institute of Mining Engineers were present at the meeting and unanimously adopted the following resolution:

Whereas, the engineering profession is threatened with the passage of a Licensing Bill at Albany by the New York State Legislature, and

Whereas, the legislation proposed by the bills now in committee will operate to the serious disadvantage of our profession and the business interests of the State;

Now, therefore, be it resolved, That it is the unanimous opinion of the undersigned that it is to the interest of the engineering profession and the public that no license bill whatever be passed and that the presidents of the engineering societies be requested to appear in person, or by representative, at Albany at any of the hearings before the legislative committee which has the matter in charge, and vigorously oppose the passage of any bill for licensing engineers; and also that the various representatives of the societies, as above, shall get together to insure coöperative action.

Cary T. Hutchinson	S. L. F. Deyo
William Barclay Parsons	Rudolph Hering
Allen Hazen	Ralph D. Mershon
W. J. Wilgus	H. de B. Parsons
A. A. Stuart	Samuel Whinery
Ralph Chambers	A. W. K. Billings
Henry W. Hodge	George B. Francis
Calvin W. Rice	Frank J. Sprague
Charles Whiting Baker	E. D. Meier
Alfred P. Boller	R. S. Buck
L. B. Stillwell	

These resolutions were printed and distributed among the engineers of New York State.

On March 1, the Hoff Bill was considered by the Committee of the Assembly on General Laws. The bill was opposed in short speeches of five minutes each by E. D. Meier, President Am.Soc.M.E., A. P. Boller, R. S. Buck, E. G. Spilsbury, Mem.Am.Soc.M.E., G. B. Francis, F. J. Sprague, and P. C. Ricketts, Mem.Am.Soc.M.E., who spoke against any and all bills; and by Judge Danneher, retained by the Technical League of America, who opposed only the Hoff Bill and announced his intention of favoring the McGrath Bill. Mr.

Tillson, representing the Brooklyn Society of Municipal Engineers, was the only one in favor of the Hoff Bill.

On March 14, a special committee again appeared before the Committee on Public Education to consider the McGrath Bill. Mr. Elliot, President of the Technical League of America, and Judge Danneher, counsel for the League, spoke in favor of the bill but offered to cut out each item to which the speakers raised objection. The principal speakers against the bill were Mr. Merritt, minority leader in the House, James M. Dodge, Chairman of the Committee on Public Relations of the Society, Dean R. C. Ricketts, Mem.Am.Soc.M.E., representing Cornell, Rensselaer and Syracuse Universities, Alfred P. Boller, Col. E. D. Meier, President Am.Soc.M.E., E. G. Spilsbury, Mem.Am.Soc.M.E., and Frank J. Sprague. A resolution passed by the Engineering Society of Eastern New York, against any and all engineers' license bills, was presented by their secretary.

A special committee of engineers appointed by the General Committee, consisting of Col. E. D. Meier, President Am.Soc.M.E., Chairman, Alfred P. Boller, R. S. Buck, C. W. Baker, Mem.Am. Soc.M.E., George B. Francis, E. G. Spilsbury, Mem.Am.Soc.M.E., and Frank J. Sprague, is now collecting information in regard to the Hoff Bill, with a view to bring pressure to bear to defeat it. The principal danger in laws of this kind lies in the fact that if New York passes such a bill, many, if not all, of the other States will follow, and this will prove a tremendous burden on all engineers who have occasion to do professional work in different States, as reciprocity between them all will be difficult to obtain. It is proposed that when the question has been settled in New York State, the main arguments evolved in the discussion shall be printed and sent to the membership of the national societies, with the suggestion that they use these facts in opposing similar bills hampering the profession in their States.

The Legal Aid Society asked the coöperation of this Society in furnishing technical advisers and the Council was pleased to respond that such nominations would be made when requested.

Calvin Tomkins, Commissioner of Docks, invited the Society to appoint a committee to coöperate with the city in the solution of the problem of handling freight at terminals. The Council did not find itself in a position to undertake such duties for the present, but Commissioner Tomkins was invited to present a paper before the Society at one of its local meetings.

Another matter considered was the invitation of the Mexican

Government asking the assistance of the Society in placing graduates in engineering positions. The Council most cordially responded, expressing willingness to give publicity to such a request by an announcement in The Journal of the availability of such graduates.

James M. Dodge, Chairman of the Committee, elected for a term of five years, has been obliged to withdraw on account of the many demands upon his time; he will, however, continue to serve on the Committee.

Respectfully submitted,

J. M. Dodge, *Chairman*	
R. W. Hunt	*Public*
D. C. Jackson	*Relations*
J. W. Lieb, Jr.	*Committee*
F. J. Miller	

REPORT OF THE RESEARCH COMMITTEE

The activities of the Research Committee during the past year are not entirely revealed by the tangible results which have been accomplished. All that has been done must be regarded as preliminary to actual work.

The Secretary's office, under the direction of the Committee, has improved and extended its directory of the men who, as mechanical engineers, are engaged in work of scientific research in this country. There is also a directory of the laboratories in which these men are working. In the process of perfecting this record, an inquiry was made of 88 technical schools and universities, 63 of which number have reported. The list includes 5 physical laboratories, 15 chemical laboratories, 5 metallurgical laboratories, 33 electrical laboratories, 1 laboratory for the study of illumination and 54 dealing with problems of interest to the Committee. Of these 54 laboratories, 47 are especially equipped for steam engineering, 44 for gas engines, 33 for hydraulics, 26 for testing materials, 21 for refrigeration, and 6 for fuels. A small number are prepared for work in compressed air, for a study of oils, for sugar-house engineering, for the testing of road materials, for railway engineering, and for heating and ventilating. This information constitutes a permanent record in the file of the office of the Secretary and is available to all members.

There have been two formal meetings of the Committee, one in New York on December 6, 1910, and the other in Pittsburgh on June 1, 1911.

One of the results of the December meeting was a decision on the part of the Committee to ask authority of the Council to appoint sub-committees, which authority was duly given.

At the June meeting some progress was made in the development of plans for the sub-committees. The present status of this matter is as follows:

A Sub-Committee on Safety-Valve Investigation, which is to deal with the whole question involving the action and the efficiency of safety-valves, is in process of formation under the chairmanship of R. C. Carpenter, a member of the Research Committee. The personnel of this sub-committee cannot at this time be reported.

It has been proposed to have a Sub-Committee on Researches in Mechanical Properties of Materials Used in Electrical Engineering, and R. D. Mershon, a member of the Research Committee, has been asked to act as Chairman.

The advisability of having a Sub-Committee on Fuel Utilization was considered, and it was voted that the Gas Power Section be advised that the Research Committee will depend upon it to cover this field. The Gas Power Section has been so advised.

It was agreed that there should be a Sub-Committee on Pneumatics and Aeronautics, but such a sub-committee has not yet been formed.

Your Committee desires in this connection to give some expression of the service performed as a member of the Committee by James Christie, whose death has occurred during the past year. Mr. Christie was among those who were faithful in attending Committee meetings and who gave to the deliberations of the Committee his best attention. His successor upon the Committee has not yet been appointed.

There has been formed a Sub-Committee on Steam Devices, the personnel of which is as follows: R. H. Rice, Member of the General Research Committee, Chairman; C. J. Bacon; E. J. Berg; W. D. Ennis; L. S. Marks; Max Patitz. They report concerning the present state of knowledge of the laws governing the transmission of heat through metallic tubes from gases and liquids to gases and liquids, that it is now rather definitely established that in the general case, the heat transfer takes place in at least three separate operations:

a The transfer from the warmer fluid to the initial surface of the tube.

b The heat passage through the tube wall from the warmer surface to the cooler surface of the tube.

c The transfer from the secondary tube wall to the cooler fluid.

This has been expressed by the general equation of Peclet

$$\frac{1}{k}=\frac{1}{c}+\frac{1}{q}+\frac{1}{r}$$

where

k = the coefficient of heat transmission.

q depends on the thermal conductivity of the tube which is known quite accurately and equals $\frac{K_t}{D}$ where D = thickness of tube; K_t = a constant depending on the material of which the tube is made.

r (following Osborne Reynolds) $=\frac{d_w v_w}{B}$; or (following Josse) $= 510\sqrt{V_w}$; where d_w = density of the cooling fluid, V_w = velocity of cooling fluid, and B = a constant.

c (following Pickworth and Nickolson) $= 1.2V_s + 29400d_s - 306$, an empirical formula where V_s = velocity of the hotter fluid and d_s = its density.

As compared with c or r, q is always so large that in practical problems it can be neglected; in other words, the heat-transferring capacity of metallic tubes is always largely in excess of the heat which is brought in contact with the tube surface. For this reason, it is much more convenient to use a simpler expression, such as $K=C\sqrt{V_w}$.

Fourier stated the law as follows:

$$dH=KSdz(T-t)$$

where S = surface, z = time, and T and t = temperature. When S and Z are unity, this expression becomes $H=K(T-t)$ and $(T-t)$ corresponds to θm in our modern expression. $H=N$, the total heat transferred and $K\theta=C\sqrt{V_w}\theta$ which is the form commonly used today.

There are many practical problems connected with the determination of the laws of heat transfer. Some of the more important are:

a The transfer from flue gas under the conditions existing in economizers. Here the transfer is of the order of 2 B.t.u. per sq. ft. per hr. per deg. difference of temperature.

b The transfer from flue gas to boiling water under boiler conditions (feedwater heated to steam temperature). Here the transfer is of the order of 10 B.t.u. per sq. ft. per hr. per deg. difference of temperature.

c The transfer from flue gases to steam or air under superheater or air heater conditions. This transfer is of the order of 4 B.t.u. per sq. ft. per hr. per deg. difference of temperature.

d The transfer from hot air to colder water under air cooler conditions. This is of the order of 4 B.t.u. per sq. ft. per hr. per deg. difference of temperature.

e The transfer from condensing steam to water under surface condensing conditions. This is of the order of 1500 B.t.u. per sq. ft. per hr. per deg. difference of temperature, when no air is present, but falls off to 500 to 600 B.t.u. when an ordinary amount of air is present.

There seems to be an essential difference in the action when a condensible gas or vapor is the high temperature fluid. Here the vapor gives up its latent heat to the colder tube and contracts enormously in condensing, causing an exceedingly rapid flow normal to the tube. It may be that an analogous action takes place when the colder tube is exposed to the "bombardment" of radiant heat, as in the case of boiler tubes exposed to the rays from white hot surfaces or fuel or brickwork. Professor Bone in his lecture before the Royal Society last year stated that he had obtained in an experimental boiler an evaporation as high as 41 lb. of water per sq. ft. of surface, which corresponds to approximately 25 B.t.u. per sq. ft. per hr. per deg. difference. This was due to the radiant heat condition. Probably the best exposition of the problem where a permanent gas is the hotter fluid is given in Professor Dalby's report to the Institution of Mechanical Engineers, October 29, 1909, and his conclusions summed up on pages 25 to 28 show the exceedingly difficult nature of the problem and the necessarily costly means which must be used for its complete solution. The main factor is the determination of the temperature gradients in all parts of the boiler. That this is also true of the condenser conditions may be seen from the work of Smith and Josse and the paper read by Mr. Orrok before the Society last year.

The "mass flow" theory of Osborne Reynolds and Jordan seems to be another form of stating the fact that where more heat is present more is transmitted, and it is known that this is true up to the limit of heat transfer. Kreisinger and Ray have investigated this problem,

with an experimental boiler using air heated electrically as the hotter fluid, and their results have been widely quoted. The work of Perry developed by Breckenridge in Bulletin 325 of the Geological Survey is also of great value in this connection.

Summarizing, the lines of work which will be most fruitful are as follows:

a A final determination of the radiant heat law (Stefan's law) with a separation from conduction and convection problems. It is probable that Stefan's law is nearly correct, but does the black body condition exist, and between what ranges of temperature? Bone's experiments seem to show that it may exist at temperatures below red heat. (See Bulletin No. 8, Department of Mines.)

It is known that in boiler conditions radiation is much more efficient than either conduction or convection. How much of the heat study can be developed as radiant energy? Both Nicholson and Bone claim that the boiler of the future will depend largely on radiation rather than conduction.

b More study of the phenomena of heat transfer in the absence of radiant energy (if this is possible). What is the effect of dust and soot in the gases? Do the dust particles act as black bodies and give out radiant energy? It has been stated that 98 per cent of the temperature drop took place in the passage of the heat from the gas to the tube surface. Is this statement correct, and if so, can the "gas film" be removed or made a better conductor?

c Determination of the temperature gradient under a variety of practical conditions, and with full size apparatus. Does the gas film give more trouble when inside a fire tube with axial flow of gases or when outside a water tube with a flow across the surface.

d A determination of the law of temperature rise in the water flowing in a condenser tube. The tube should be long and the thermometers numerous.

e A repetition of Smith's experiments with the addition of known amount of air and with the use of very sensitive thermometers. This series should include all commercial vacuums, and the lower end of the steam table should be recalculated with much smaller intervals for use in interpreting the results.

f The expressions radiant heat, latent heat, etc., have been used.

Sensible heat is defined as molecular motion. Radiant heat has been defined as ether waves. When latent heat is set free as in a condenser, is it molecular or ethereal in its constitution? In chemistry, when an element is set free from combination, there is what is known as the nascent state. Does an analogous action take place when heat is set free from the latent state?

Some of these questions should perhaps be answered by the physicist rather than the engineer, but seem to the Committee to be true engineering problems to be studied through their applications if a complete, reasonable and satisfying theory is to be obtained.

Respectfully submitted,

W. F. M. Goss, *Chairman*
R. C. Carpenter
R. D. Mershon
R. H. Rice
Research Committee

NECROLOGY

HENRY W. BULKLEY

Henry W. Bulkley was born in New York, in July 1842, and died in East Orange, N. J., November 6, 1911. During the Civil War he served in the Navy as assistant engineer, abandoning his studies at the College of the City of New York in order to enlist. At the close of the war he secured employment at the Morgan Iron Works as mechanical draftsman and constructor. Shortly afterwards he opened an office of his own in New York as constructing and consulting engineer and engaged in the manufacture of the Bulkley injector-condensor, superheater, steam pumps, etc., continuing in this work until the time of his death. He was the inventor of the Bulkley injector-condensor, which he patented in 1875, as well as a special type of steam pump and improvements on superheaters.

Mr. Bulkley was a member of the American Institute of Mining Engineers and the American Institute of Electrical Engineers.

THOMAS B. DAVIS

Thomas B. Davis was born at Forest City, Ark., in 1876, and received his early education in the public schools and in the State University of Arkansas. After spending two years as draftsman on steel mill buildings, contracting plants and smelters in Denver, Colo., he studied for one year at Cornell University, securing upon its completion a position as designing engineer with the American Smelting and Refining Company, New York, later going to Mexico as designer and superintendent of erection of the concentration mill at Santa Barbara, Chihuahua. Upon his return he accepted the chair of applied mathematics and machine design at the University of Nebraska, Lincoln, but after a year accepted a position as mechanical engineer with the Jeffrey Manufacturing Company, of Columbus, Ohio. While with this company he made estimates on and designed the cranes for handling the rock, sand, cement and concrete for building the locks at the Isthmus of Panama, manufactured by his company, and in December 1908, was asked by the Government to accompany the United States Engineering Corps to the Isthmus

to look over the field and become familiar with the surroundings prior to the beginning of the steel work, one of the most gigantic undertakings in this line ever considered in this country. The success of Mr. Davis's work gave him a wide and enviable reputation for competency in his chosen field. At the time of his death, November 3, 1911, he was president of the Arkansas Farm Company of Little Rock.

JOSEPH JAMES FERRIER

Joseph James Ferrier, whose death occurred at Fruitvale, Cal., October 29, 1911, was born at Brighton, Sussex, England, November 26, 1882. His education was obtained at the English common schools, and in 1904 he completed a course in civil engineering with the International Correspondence Schools, during which time he was also employed by the Linlott Engineering Works, Horsham, England, in their foundry on municipal supplies and agricultural machinery. In 1903 he came to America and obtained a position with the Mergenthaler Linotype Company, Brooklyn, N. Y., as timekeeper, draftsman, estimator and designer. Two years later Mr. Ferrier secured a position in the electrification department of the New York Central & Hudson River Railroad Company, and rose from a subordinate place to chief draftsman in the steam engineering branch of this work. In April 1907, he entered the electrical engineer's office of the Southern Pacific Company, at San Francisco, Cal., taking a prominent position in the steam and mechanical engineering branches of the Oakland, Alameda and Berkeley electrification.

THE ENGINEER AND THE FUTURE

By E. D. Meier, New York

President of the Society

If we could plot the progress of engineering in the last century in a plane curve culminating in the present, at the intersection of our axes the future would probably trace a line ascending in a great parabola.

But as we look back we can conceive of no equation which could express the achievements of the past in a single line, no matter how grand its sweep. The three dimensions which limit our knowledge of space are requisite to compass the varied activities of the engineer.

A century ago the distinction between civil and military engineer sufficed, but a few decades ago it became necessary to differentiate in turn the mechanical and the electrical engineer, while quite recently upwards of a hundred specialties were enumerated in the attempt to define the activities of the profession, each of which has its recognized experts. These are developed to fulfil the imperative demands in every art and industry for a greater refinement, precision and certainty as to the quantity and quality of the product.

Slowly but surely the superstitions and traditions which have so long encumbered our social life and hampered our free development, are exposed and annihilated by the altruistic labors of men who give their life to science. These are the high priests of the new dispensation. It is the duty, the glorious privilege of the engineer to receive their discoveries with reverent hands, and apply them to the solution of the practical problems of life.

Both these types of men are essentially modern products of an evolution which counts not by centuries, but by ages. Before the first Cain of the stone age could appropriate the fruits of his brother Abel's labor there was a mechanic who fashioned his stone axe as patiently as he had lashed the pole to the curved branch with which Abel ploughed. The lame blacksmith who hammered out the greaves of Achilles and chiseled a whole panorama of barbarous

Presented at the Annual Meeting of The American Society of Mechanical Engineers, December 1911.

deeds on his bossy shield, stood in such high repute among the warlike Greeks that they voted him a place among that rather disreputable coterie which ruled the small world of the day from Mount Olympus. Some centuries later there were a Democritus, a Bion and a Euclid, who developed geometry. But the clumsy method of numerical notation and the absence of algebra made the application to practical problems almost impossible. And the unfortunate habit of the noblest minds among the ancients to lay more weight on methods of reasoning and theoretical speculations than on the facts on which these should be based, retarded the union of science and practice. Even the inventive genius of Archimedes was hampered by these unfavorable conditions.

Those great road and bridge builders, the Romans, produced military engineers, but theirs were mainly static problems; and even their much vaunted aqueducts show lack of coöperation between science and practice. They were carried over valleys on costly structures inviting diversion or destruction at the hands of the enemy. With their excellent cement and their knowledge that water always seeks its level, their engineers might have built subterranean conduits.

The great engineer of the Renaissance, Leonardo da Vinci, with prophetic prescience conceived in the sixteenth century projects which the nineteenth and twentieth were to carry out in the light of scientific facts entirely unsuspected in his day.

The seventeenth and eighteenth centuries were engulfed by wars predatory and dynastic, and even the fierce upheaval of the French Revolution and the drastic destruction of feudalism by Napoleon left alive modes of thought based on an exaggerated reverence for the philosophy of Greece and Rome.

Early in the nineteenth century the scientific method came into vogue, and henceforth problems were studied and defined before their solution was attempted, and more intellectual labor expended in ascertaining facts than on reasoning about them. Thus the union between the mechanic and artificer and the student of nature's eternal laws became possible and permanent, and engineering developed from an art into a profession.

The men who spanned the Hellespont for the hosts of Xerxes, those who dug the irrigation canals which made Mesopotamia the granary of the ancient world, those who designed and built the engines with which Alexander battered the walls of Persian strongholds, those who cumulated the puny muscular force of thousands of

Egyptian slaves for the herculean task of raising the pyramids, all these men were giants in their day; but now their very names are forgotten. The literature of that day and for long afterward was concerned mainly with kings and conquerors. Jurisprudence and medicine shared in some slight degree the attention and prestige which were almost wholly absorbed by war, and can hence trace their history back to the ancient world. Democritus was one of the few ancients with scientific bias; knowing his surroundings we can understand why he became the "laughing philosopher."

Engineering is the profession of the present, and will dominate the future.

Laws have been made by men ever since the family expanded into the clan or tribe. They naturally reflect the ethical standard of the average mind of the period. Far in advance of them are the precepts laid down by those who founded the great religions of the world. And as we reverently discover and apply natural laws, we find new reasons and supports for these fundamental ethical conceptions.

The engineer then is a devout believer in natural laws. He knows that they are immutable and permit no exceptions. He needs no Supreme Court to define them as reasonable. They are the very foundation of the universe, and reason itself owes its existence to them. Every infraction of them brings its own punishment. The knowledge that every mistake or neglect inevitably results in failure is ingrained in the very fiber of his being. The vile doctrine evolved in the dark ages, "the king can do no wrong," which still causes occasional lapses of justice, has no meaning for the engineer. To tell the truth is not merely laudable and salutary, it is essential and necessary. To lie is not only wicked, it is ineffectual, absurd and ridiculous.

To men thus trained, the future of the race is to be confided. They are not to be merely learned men; they must possess knowledge. Those fundamental sciences which observe and explain the interrelation of matter and force, which weigh the distant planets and measure the wave lengths of sound and of light, must be the absorbing objects of their nightly vigils and their all-satisfying reward.

The savage hated work, and even in those golden periods, praised by romancers masquerading as historians, labor was despised as the doom of the slave. As progress demanded more and higher types of labor, various devices were invented to secure it. From the glass beads and the brass bangles of the Hottentot to their counterparts in polished stone and burnished gold in civilized communities, these

devices were effectual; but the highest type of labor has never been purchased by such crude bribes. The enlightened man loves his work and finds in it his supreme incentive.

To a Copernicus or a Newton, a Watt or a Corliss, an Ericsson or a Fritz, an Edison or a Steinmetz, the ransom of a king would seem trivial compared with the satisfaction of knowing that he has given to his fellow men an achievement which marks a forward step in the evolution which will finally make us a race of rational beings.

When the "missing link" stood erect, walked and essayed articulate speech, this evolution began. The first man had crude but strong desires, and was a strenuous individualist. The predatory instinct was predominant, and the success of the family, the clan, the tribe, and finally the nation, depended on the potent warrior at its head. Laws and customs modified this predatory individualism in each community, but between neighboring communities there still held the rule, that

> "He shall take who has the power,
> And he shall hold who can."

The right of the mailed fist is still occasionally invoked by great nations, even though the individual citizens have been tamed and domesticated.

Commerce, which has in large measure wrested the control of the world from the war lords, has always had as its basic principle the rule, "Buy as cheap as you can, sell as dear as you can."

This has worked fairly well when cargoes of grain, wool, cotton, hemp, etc., were concerned. But where this principle was ruthlessly applied to the great producing industries of the world, where the comfort of the worker, the maintenance of his family, the very existence of his helpless children were in jeopardy, it has caused havoc, bred discontent and fomented revolution. No one who has worked among the contented, intelligent mechanics of a half century ago can view without distress and indignation conditions as they exist today. Labor unionism is a protest, dangerously near a rebellion, but not a cure.

When the commanders of the industrial soldiery wrought in their midst, understood their problems, solved their perplexities, aroused and shared their enthusiasm for the quality of the product there grew up an esprit de corps which is now sadly missing.

Without faith in the excellence of the goods produced, without enthusiasm in the work and in the leaders, productive labor becomes

mere drudgery. The remedy lies in placing engineers in all the responsible positions in these great industries. Their special training fits them for leadership in this host; and leadership by him who knows, and who sinks himself in his work, always has and always will command that joyous and fervent support from his followers which money cannot buy.

Where nepotism is banished, and ability and perseverance are recognized, there great success is attained. Napoleon's army, the Carnegie Steel Works, the Pennsylvania Railroad, exemplify this. The increasing multitudes of special industries are literally hungering for engineers equipped with character, knowledge and devotion, to become the expert leaders.

Labor wars will cease when such men are given the power to provide that the share in the rewards of industry shall bear just ratio to the service rendered the community. There is a sane middle ground between grasping individualism and utopian socialism.

The forces and materials we employ in our manufactures have long been and still are the subjects of most careful analysis and experimentation, to find their precise load capacity and endurance. The study of the living force and of that highest and most costly material inherent in the workman has but recently begun. But already several promising theories are undergoing exhaustive tests on a large scale. Psychological study prescribes a humane basis for them all as the condition of success.

The unrest in the modern world has its basis in an underlying sense of injustice. The growing sense of community of interest, the knowledge of our dependence on each other, the ever-expanding humanitarianism, are all founded on scientific facts, and are becoming world movements. They fervently and emphatically answer Cain's question, "Thou art thy brother's keeper."

The engineer is responsible for the vast increase in appliances to meet every demand of that most voracious of living beings, man. The mass of mankind needs to be educated to understand and use them properly. He is in honor bound to supply this education; and as the crude dangers and fears of the earlier centuries vanished, so the prejudices and superstitions of the Dark Ages must be swept away.

If our future professional brethren do their duty, and we know they will, the golden rule will be put in practice through the slide rule of the engineer.

SYMPOSIUM ON WELDING

. MODERN WELDING PROCESSES

WITH SPECIAL REFERENCE TO FLAME WELDING

By H. R. Cobleigh, New York

Junior Member of the Society

Welding may be divided into two general classes, pressure welding and casting. The oldest and commonest process, where the forge is used for heating and the uniting of the metals effected by hammering, belongs to the first class, and only one of the newer processes, electric resistance welding, comes within the same classification. The pioneer in the second class was "burning on," a process of local casting where the parts to be united were first preheated to a state to amalgamate with molten metal poured in to complete the joint. Another electric process, arc welding, and all of the gas or flame-welding processes, belong also to this second class.

2 A distinction in procedure differentiating the older from the newer processes is, in a measure, the greater portability of the latter; more exactly, in the older processes the work is brought to the heat, or the source of the heat is apart from the immediate vicinity of the place where the welding is done, while in the newer processes the reverse is true.

3 Autogenous welding has become the accepted name for arc, flame and sometimes thermit welding, but it is a misnomer. Strictly speaking the term means either self-welding, which is ridiculous, or welding with the same metal, whereas two different metals are often united, sometimes with a third metal, and the result is not comparable with brazing or soldering as there is a more intimate molecular union. In the real sense of the word it is not welding, for there is no compression, or hammering, except incidentally as practised by some in the belief that it improves the structure of the added metal. It is more analogous to casting, since the union is made by the flow-

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ing together of the metals, but that word alone is even more ambiguous. Fusion welding would be a good term but it has been appropriated by another new process abroad which is more akin to brazing. However, as that process does not appear to have taken any important place in the arts, there is probably no reason why it should not be applied to what is now called autogenous welding, or auto-welding for short. One of the simplest definitions of autogenous welding is the uniting of metals by heat alone.

THERMIT WELDING

4 Thermit welding is the outcome of the discovery in Germany about the beginning of this century that a mixture of finely divided metallic oxides and aluminum, when ignited at one spot, react to form a new combination of aluminum oxide and free metal, formerly in the oxide form, due to the greater affinity of the aluminum for oxygen. This reaction is accompanied with an evolution of heat in which a temperature of 5400 deg. fahr. is obtained. In the resulting molten mass the lighter aluminum oxide rises to the top where it can be skimmed off as slag, leaving the other metal in a superheated state, which, when poured into a mold surrounding the parts to be joined, contains sufficient excess heat to bring those parts to the point where they will amalgamate with the added metal, so that the whole solidifies as a homogeneous mass. Usually, however, it is advisable to preheat with a gasolene torch the parts to be joined, and thus by eliminating the gases produce a better casting.

5 The commoner form of thermit contains iron oxide and aluminum, and the reaction follows the formula $Fe_2O_3+2Al=2Fe+Al_2O_3$.

ELECTRIC WELDING

6 Beyond the fact that electric current is used for obtaining the welding temperature, the two kinds of electric welding, arc and resistance, have no similarity. Comment on the electric processes will be limited in this paper to the electric resistance welding. The principle discovered by Elihu Thomson involves the passage of electric current through the abutting ends of the pieces of metal to be welded, thereby generating heat at the point of contact, which also becomes the point of greatest resistance, while at the same time applying pressure to force the parts together. As the current heats the metal to the welding temperature at the junction the pressure follows up the softening surface until a complete union or weld is effected. It is claimed that in all other processes, the heat not being

generated in the metal or in the joint to be welded, is largely dissipated and wasted. In the Thomson process the heat is generated in the metal itself at the joint, and practically confined there; the energy is therefore economically employed. When the weld is made, the structure of the metal at the joint is the same as elsewhere. The metal can be held at any temperature desired for any length of time and the heat increased or decreased at will. The metal while heating is visible in the open air. Being unattended with smoke, heat or dirt, the apparatus employed can be located wherever convenient or desirable.

7 Various forms of machines are built, but the main essentials in all of them are a transformer provided with a pair of clamps aligned with and insulated from one another to hold the pieces to be welded, and mechanical, hydraulic or other means to force the abutting ends of these pieces together. In some forms there are additional mechanical features for shaping the weld after it is completed to remove the fin, as by striking between two dies. Contrary to ordinary welding, the heat begins at the interior and travels to the exterior, impurities thus being expelled. There is no current expense except when heating, little to wear or occasion repairs, and unskilled labor can operate the machines. A reactive coil is used for controlling the current in the welder for varying sections of stock to be welded. In the smaller types the pressure is applied and the current shut off automatically. In all but the smaller types provision is made to maintain a circulation of water in the secondary circuit for cooling purposes. By means of a break-switch the circuit is opened and closed in the primary of the welder; in some types automatically.

8 The apparatus is built in sizes and types suited to the kind and section of the metal to be welded, these usually ranging from small wire to sections of 3 sq. in. Only alternating current is used, taken from a single phase of any constant potential, 40 to 60 cycle, between 100 and 500 volts. In general the process is particularly applicable to the butt welding of relatively small and similar sections, i. e., the parts to be joined should be of approximately equal cross-section. Among the most common in the very wide range of applications of this process are the welding of metal tires of all kinds and other parts in the running gear of wagons and carriages, bicycle parts of all kinds, parts of tools, wire of all kinds for such purposes as hoops, fencing, etc., pipe chain, parts used in street railway construction, miscellaneous automobile parts, and the like.

9 Fig. 1 shows a semi-automatic welder for wire, with the sides of

the base removed to expose the transformer. Figs. 2 and 3 are front and rear views respectively of a chain welder installed for the Yale & Towne Manufacturing Company, and used for welding the links of hoist chain, and a slightly different machine for welding seamless tubing is shown in Fig. 4.

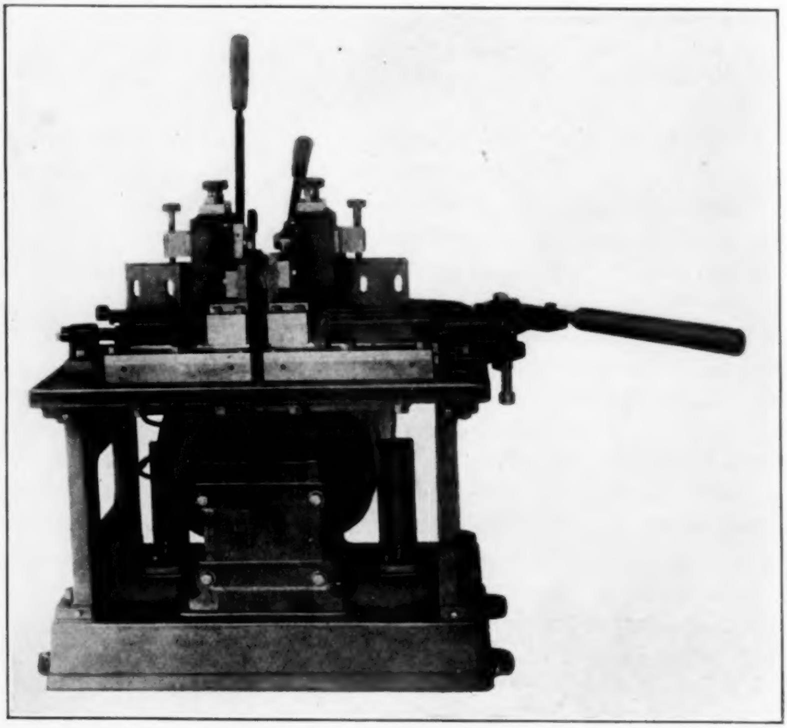

FIG. 1 THOMSON SEMI-AUTOMATIC ELECTRIC WELDER FOR WIRE

10 The output of a single machine varies according to the size of the weld and the shape of the pieces to be welded, and depends in a great measure upon the operator. If the work is light and takes little time to adjust in the machine, very large outputs are possible. The horsepower and time required to make a given weld vary nearly as the cross-sectional area. Within certain limits the greater the power the less the time, and vice versa. With 15 kw. a $\frac{3}{4}$-in. round can be welded in 15 seconds and with 23 kw. in 6 seconds. Endless pieces like rings take more power as the diameter decreases; copper more power and less time than steel or iron.

11 Table 1 from the catalogue of the Thomson Electric Welding Company gives the approximate normal power and the time (for the application of the current only) for various sections. Multiplying the kilowatt-hours by the cost of the current in cents per kilowatt-hour will give the current cost for 1000 welds.

12 One of the latest applications of the process is the welding of

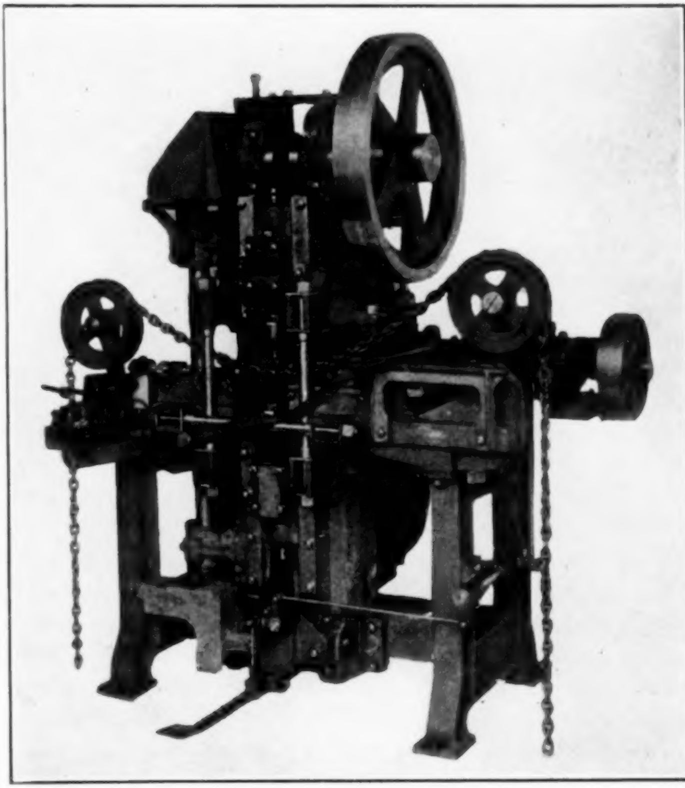

Fig. 2 Front View of Electric Chain Welder

platinum points on steel and brass pins. The manufacturers' principal line of endeavor now is to increase the rapidity of working and reduce the cost of operation. At present butt machines are operating at a rate of 20 welds a minute, and point welders making five to ten welds at a time and working automatically. Spot, point, ridge and jump welding are inventions of the Thomson Company, which is now building machines for this work. A rather new commercial develop-

ment in electric welding is that of welding halves of casters, handles, etc., in semi-automatic machines to make the whole article. The smallest Thomson machines weld No. 23 wire and the largest sections of 3 sq. in.

TABLE 1. APPROXIMATE NORMAL POWER AND TIME FOR VARIOUS SECTIONS

Iron-Steel Round Rod	Area	Horsepower	Kilowatt	Seconds	Approximate Kw-Hr. 1000 Welds
$\frac{1}{4}$	0.05	5	4	2	2
$\frac{3}{8}$	0.11	8	6	3	5
$\frac{1}{2}$	0.20	12	9	6	15
$\frac{5}{8}$	0.31	16	12	10	30
$\frac{3}{4}$	0.44	20	15	15	65
$\frac{7}{8}$	0.60	24	18	18	90
1	0.79	26	20	20	113
$1\frac{1}{8}$	0.99	33	25	24	167
$1\frac{1}{4}$	1.23	40	30	33	275
$1\frac{1}{2}$	1.77	50	38	40	422
$1\frac{3}{4}$	2.41	64	48	48	640
2	3.14	80	60	60	1000

FLAME WELDING

13 Of the different kinds of torch or blowpipe welding, the two of the greatest present commercial importance are oxy-hydrogen and oxy-acetylene. Air-gas and oxy-gas (coal gas) torches are also used, but they do not give as high temperatures as either the oxy-hydrogen or oxy-acetylene torches and are generally considered not well adapted either to welding or cutting, but useful mainly for soldering and brazing. Another flame process, which, as far as the author is aware, has never been introduced into this country, uses "liquid gas," discovered by M. M. Wolf of Basseldorf, Switzerland. The oxy-liquid gas flame is claimed to give a temperature of 7000 deg. fahr., which is even higher than oxy-acetylene (6300 deg. fahr.). It is declared to contain 2500 more thermal units per cubic meter than acetylene. The flame of the oxy-liquid gas torch has much the same appearance as the oxy-acetylene flame. Blau gas which has been introduced in this country seems to be closely analogous to liquid gas and gives the same temperature. Its possibilities for welding and cutting give great promise.

14 Liquid gas is obtained by distilling heavy oils such as paraffin oils, crude petroleum and the like. The distilling and cleaning processes are the same as in the manufacture of any oil gases. Wolf's special process involves the abstraction of heat and the employment of pressure to separate the gases that are the hardest to liquify, as hydrogen, methane, etc., from those liquified more easily, such as

ethane, propane, pentane, etc. It is charged into steel bottles at 1200 to 1500 lb. pressure, making it again liquid, from which state it gasifies readily at atmospheric conditions into dry inflammable gas, containing none of the poisonous hydrocarbons. It consists principally of ethylene and ethane, with small quantities of methane,

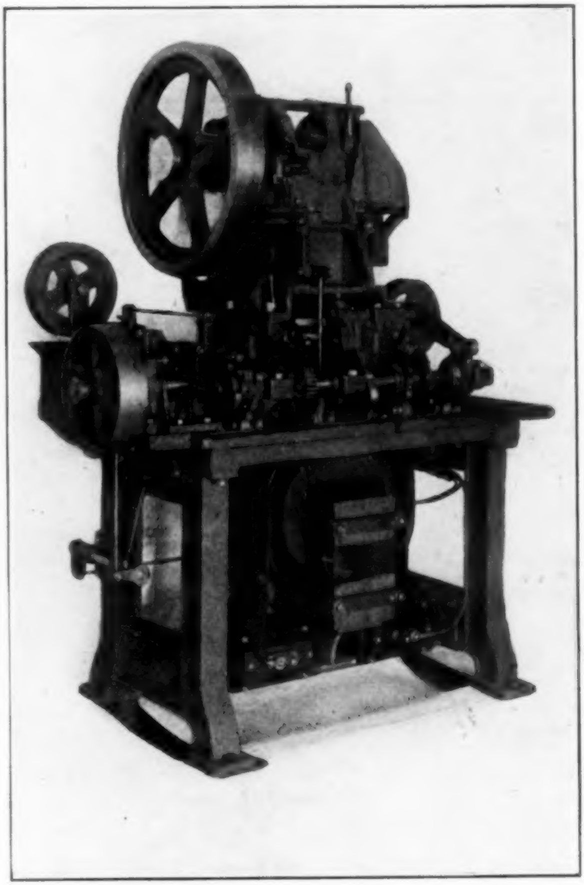

Fig. 3 Rear View of Electric Chain Welder

benzol, air and carbon dioxide. It is explosive only in mixtures containing 4 to 9 per cent of gas, hence is much less likely to explode than city gas or acetylene. Being 1.027 times heavier than air it does not easily mix with air, which still further reduces danger of explosion.

15 The torch with which this gas is used does not require as great provision against back-firing as the oxy-acetylene torch. An air chamber keeps the handle cool, through which the gas and oxygen are passed to a mixing chamber in the front half of the body of the torch. At the rear of this chamber the gas is carried through a pipe coiled around the stem of the torch, and in this way is preheated. Oxygen passes out the forward end of this chamber through another pipe which meets the gas pipe at the nozzle of the torch. Through

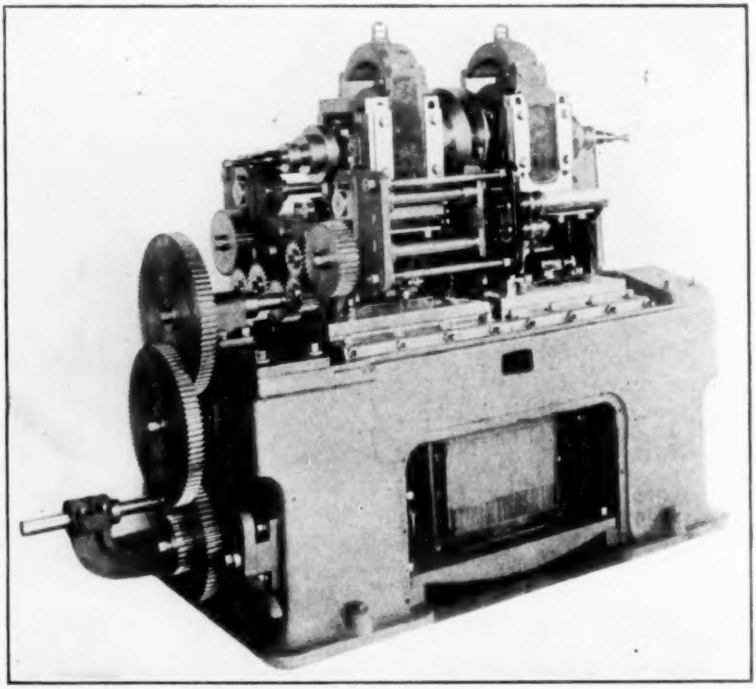

Fig. 4 Machine for Electric Welding Seamless Tubing

the central stem is carried the mixed gas, and the three are combined at the nozzle into a good mixture for combustion. Only three tips are needed for welding or cutting any thickness. The cutting torch has the usual high-pressure oxygen supply and does not require the preheating coil for the gas. Neither the gas nor the products of combustion attack metal, hence the burners, torches and fittings last a long time, and the gas does not injure the metal in the joint, so that strong welds result.

THE OXY-HYDROGEN PROCESS

16 The oxy-hydrogen process, although older than the oxy-acetylene process, has not been developed quite as rapidly, although for certain applications it has the advantage of its competitor. The torch is simpler because flame propagation in hydrogen is not as rapid as in acetylene and less precaution is necessary to prevent flash-back. In fact all that is necessary in such a torch is two conduits for the gases with a common nozzle from which they are discharged mixed. In its simplest form we are all familiar from our laboratory days with the oxy-hydrogen blowpipe. Any refinements that have been introduced since the industrial application of the torch has been appreciated have had for their object greater convenience in handling, directing or controlling the flame, according to the work to be done. For all purposes where the greater heat intensity of the oxy-acetylene torch is of no advantage, the oxy-hydrogen torch with its temperature of about 4000 deg. fahr. is as good or even better. For example, it is capable of cutting greater thicknesses of steel and wrought iron, on account of the greater penetration of the flame, and for thin welding and the welding of metals of the lower fusibilities less skill is required in its handling. Another advantage is that it makes use of a by-product of electrolytic decomposition of water, one of the best methods of procuring the purest oxygen, and a process that is becoming of important commercial significance for making oxygen for the acetylene torch as well. Further, the hydrogen can safely be compressed directly into tanks for carrying on outside operations or supplying any portable outfits, whereas acetylene, as will be explained later, must be dissolved in acetone to be handled safely when compressed above two atmospheres.

17 Perhaps the reference to hydrogen as a by-product of the electrolytic production of oxygen should be modified so far as the oxy-hydrogen process is concerned, for the fact is that more hydrogen is required than the proportion of two to one as found in water, so that there is an excess of oxygen, making this gas in that sense the by-product. The reason for this is that although hydrogen in burning returns to the form of water (or its vapor), part of the oxygen is obtained from the surrounding air, hence to prevent the flame from oxidizing the work, the supply of pure oxygen through the torch is proportionately reduced. However, the excess oxygen, if not all needed for cutting operations, will find a ready market among the users of oxy-acetylene apparatus not making their own oxygen. Then, too, it has been reported quite recently that means have been

found for carburetting the hydrogen, so that where welding alone is done the consumption of oxygen and hydrogen leaves no excess of either and the flame produced is of greater heat intensity than with

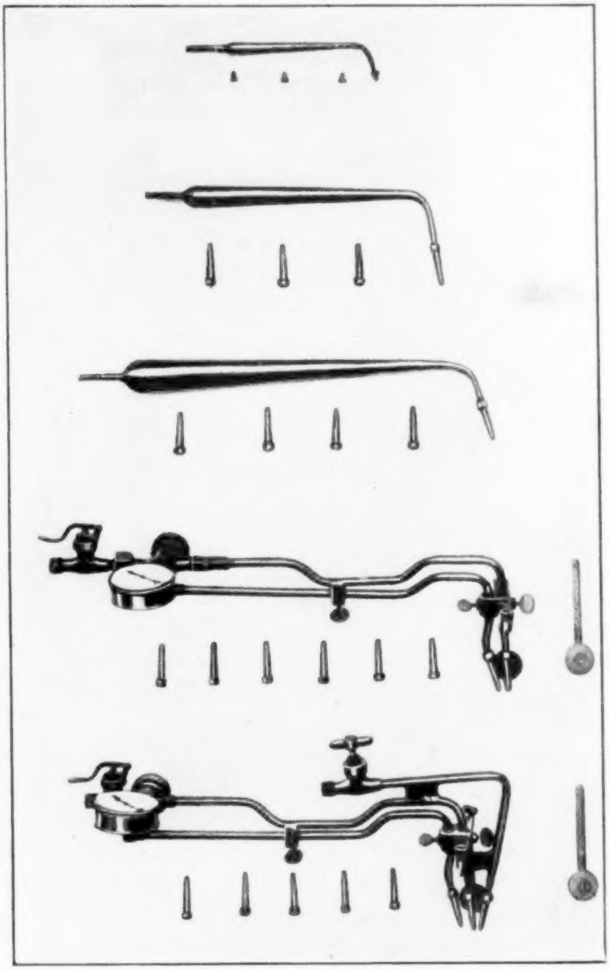

Fig. 5 Group of Oxyhydric Welding and Cutting Torches

the plain hydrogen. The ideal arrangement would seem to be the providing of all three gases, oxygen, hydrogen and acetylene, in plants of a size to warrant it, employing apparatus for the electrolytic production of the first two gases and an acetylene generator,

and using the oxy-hydrogen and the oxy-acetylene torches on the work for which each is the best adapted. There is a sufficient overlap in the profitable applications of each to introduce no difficulty in the proper relative consumption of the several gases. One of the oxy-acetylene torch manufacturers, the Davis-Bournonville Company, is now arranging to manufacture oxy-hydrogen apparatus, appreciating the value of their correlated use.

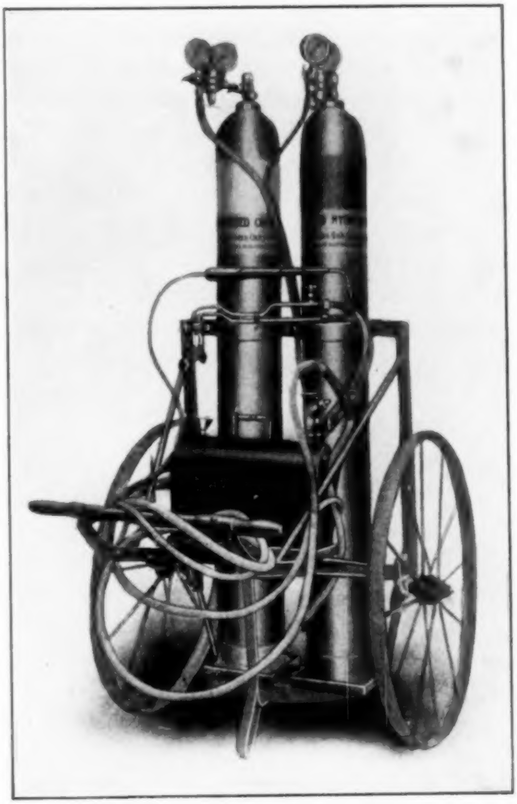

FIG. 6 PORTABLE OXYHYDRIC APPARATUS FOR CUTTING AND WELDING

18 The American Oxyhydric Company, Milwaukee, Wis., a leader in the introduction of the oxy-hydrogen welding process in this country, is responsible for the following rather interesting definitions and divisions of welding:

Welding may be divided into two classes, autogenous and heterogeneous.

The former term applies when metals are united without either flux or compression, the latter when the union is effected by interposing an alloy, usually more fusible than the metal which is to be welded. Autogenous welding may again be divided into two classes, one welding by forging, and the other by fusion with the aid of a blowpipe, electricity or alumino-thermite.

It further states that autogenous welding is particularly effective when applied to iron, steel and lead, and heterogeneous welding is used most effectively on zinc and copper, its argument being that metals which oxidize at a temperature close to the fusion point should be welded by the heterogeneous process.

19 Fig. 5 shows a group of this company's welding and cutting torches. This torch is distinguished by the fact that the mixture of the gases occurs before their admission to the torch, there being a hose between the mixer and the torch. Safety against back-firing is secured by discharging the gases at a speed greater than that of the flame propagation in the mixture and limited for its maximum by that which would tend to blow away the metal as it is melted in the weld. A portable oxyhydric apparatus for both cutting and welding is shown in Fig. 6.

GAS PRODUCTION

20 The American Oxyhydric Company has the American-Canadian rights for the Caruti system for producing oxygen and hydrogen. The process is one of decomposing water by an electric current in which oxygen is claimed to be obtained at 96 per cent purity and hydrogen at 100 per cent. The oxygen is further purified to over 99 per cent purity, the remaining impurity consisting of hydrogen. These gases are shipped to consumers in steel cylinders of 200 to 250 cu. ft. capacity. Regulators and gages are provided to reduce the gases to working pressures and show the state of depletion of the gases in the cylinders.

OXY-ACETYLENE WELDING

21 Le Chatelier has the credit of having first called attention to the high temperature obtainable in the combustion of acetylene with oxygen. This was in 1895. The discovery was not taken advantage of until 1901, when Fouché and Picard brought out a torch in which they diluted the acetylene to prevent back flashing. The following year they overcame the necessity of dilution by employing a high-pressure torch which emitted the gases at such a velocity that the flame could not strike back. This, however, was difficult to use because it blew the metal away as fast as it was melted. In 1903

Fouché introduced the low-pressure torch still familiar as such, in which the oxygen only is under appreciable pressure and the acetylene is drawn in by injector action. About the same time Camille Rodrigues-Ely and Emile Gauthier announced their intermediate pressure torch, which is known in this country as the high-pressure torch, because the one of still higher pressure has never been introduced here.

22 The first commercial installation in this country was made at the Fore River Shipbuilding Company, Quincy, Mass., in 1905, by André Beltzer, then with the Industrial Oxygen Company, the pio-

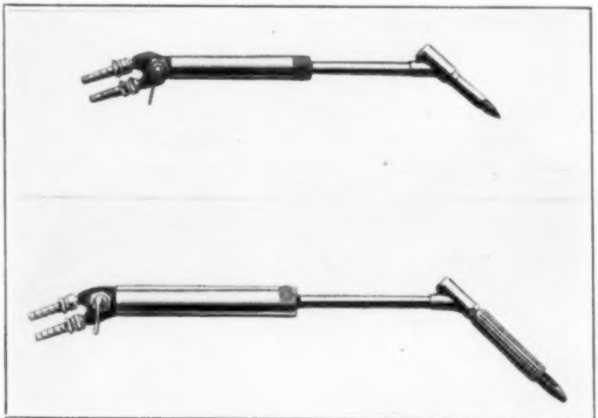

Fig. 7 Linde Form of Fouché Oxy-Acetylene Torch

neer in introducing the process here. The second plant installed by it was the Worcester Pressed Steel Company. Here the Epurite process for producing oxygen was used, which with the Industrial Oxygen Company's later oxygenite process is referred to at greater length in Pars. 45–47. The torches were of the intermediate pressure type.

23 The Fouché or low-pressure torch is the form used by the Linde Air Products Company, which gave a very great impetus to the flame-welding and cutting arts when it placed oxygen on the market at a moderate price. The process is one of obtaining it by separation from the air, and is also referred to more extendedly in Par. 51.

24 The third in the field was the Davis-Bournonville Company, which for some time had been investigating the developments abroad,

particularly in France, and which acquired the American rights for the Rodrigues-Gauthier medium-pressure type of torch.

TORCHES

25 What are commonly spoken of as low-pressure and high-pressure torches are better classified as injector and pressure, or positive-mixture types, as this is the chief distinction, indicating the manner in which the acetylene is taken in. As explained in Par. 21, the Fouché is an injector torch. The oxygen admitted under pressure draws in the acetylene after the familiar action of a steam injector, and by the law governing the action the quantity drawn in depends on the square of the velocity of the oxygen jet. It is argued by advocates of the other type that it is not easy to maintain the proper relative proportions of the two gases with this torch since any variation in the diameter of the final outlet of the nozzle (as by expansion,

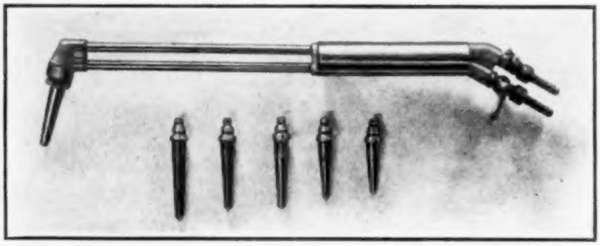

FIG. 8 DAVIS-BOURNONVILLE POSITIVE-MIXTURE TORCH

if it becomes heated during use, or by the adherence of molten particles to the end) alters the velocity of the oxygen and so the amount of acetylene injected.

26 The pressure-type torch introduces both gases under pressure and the proportion of the mixture can be varied by varying either pressure. The pressures on the gases, never over a few pounds, will depend on the size of the torch, which in turn is determined by the character of the work and the size of flame needed. These torches must either be supplied with dissolved acetylene or from a pressure generator, whereas the injector torches can take their supply from an ordinary lighting generator. Fig. 7 shows the Linde form of Fouché torch and Fig. 8 the Davis-Bournonville positive-mixture torch. The feature of the latter is the proper proportioning of the inlets to the nozzle for the two gases. As shown in the sectional view, Fig. 9, the oxygen enters at *a* in a straight line and passes through a

restricted opening before emerging into the mixing chambers, while the acetylene enters laterally through four holes *b*, and joins the stream of oxygen and mixes with it in the slightly larger bore of the mixing chamber where the velocity is correspondingly reduced, giving time for the mixture. It will be seen that the proportion of the two gases is entirely independent of the orifice diameter at the final outlet. The tips are interchangeable so that different sizes may be used in the same torch for different work.

27 The handles of all torches are now packed with porous material such as asbestos or mineral wool, or by some other means secure finely divided openings for the passage of the acetylene. An interesting construction is that of the Goodyear torch, Fig. 10, which has a piece of clock pinion wire inserted in a bore of its outside diameter, giving a number of small parallel holes for passing the acetylene.

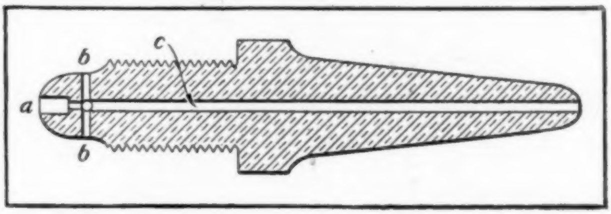

FIG. 9 SECTIONAL VIEW OF DAVIS-BOURNONVILLE TORCH

The principle is that of the Davy safety miners' lamp in preventing propagation of the flame backward, that might lead to the explosion of the acetylene generator if it happened to contain air. There are other safety provisions, however, between the torch and the generator, so that practically all danger of acetylene explosions has been eliminated except where gross carelessness in the use of the apparatus is practised. The first low-pressure Fouché torch prevented flash-back by passing the acetylene through a relatively small bore tube coiled in the handle.

28 Some favor a torch with its end at right angles with the body to allow wrist motion, but most torches have the tip inclined at about 45 or 60 deg.

THE TORCH FLAME

29 For the complete combustion of acetylene there is required two and one half times its volume of oxygen as shown by the formula $C_2H_2+5O=2CO_2+H_2O$. This is not the proportion, however, in which the two gases are supplied to the torch, for the reason that the

complete reaction takes place in two stages represented by the two parts of the flame, the intensely luminous inner cone at the tip of which the maximum temperature of about 6300 deg. fahr. is reached, and the pale almost transparent envelope of the flame where the temperature is very considerably lower. In the inner cone the reaction is $C_2H_2+2O=2CO+2H$, and its high temperature is accounted for by the liberation of heat both by the dissociation of acetylene and the formation of carbon monoxide, the acetylene being endothermic and the monoxide exothermic. The carbon monoxide and the hy-

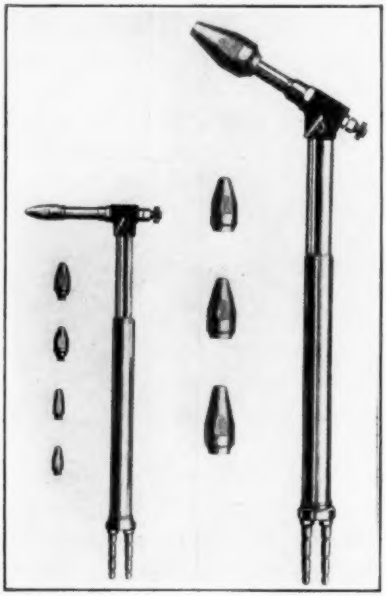

FIG. 10 GOODYEAR OXY-ACETYLENE TORCH

drogen cannot combine with more oxygen in the inner cone because its temperature is above their dissociation points, so this further combination occurs as a second stage in the reaction in the envelope of the flame and is represented by the equation $2CO+2H+3O=2CO_2+H_2O$. Most of the oxygen for this second reaction is taken from the surrounding air, hence the smaller quantity required through the torch. It is a singular fact that the injector type of torch uses oxygen in the proportion of 1.5 or 1.7 to 1 of acetylene, while the pressure torch requires only 1.28 of oxygen to 1 of acetylene. The old high-pressure torch used the gases in the theoretical propor-

tions for the inner cone reaction of 1 to 1, indicating that it evidently accomplished a perfect mixture of the gases before their discharge.

30 The tip of the inner cone is the working point of the torch. Although its temperature is so much higher, the total heat in the inner cone is less than that in the outer envelope, the latter being very much larger. It might seem that the heat in the envelope is wasted, but such is not the case for it serves two functions, to preheat the work for the inner cone, and to prevent the latter from being cooled by the inert nitrogen forming about 80 per cent of the air. Further the envelope is a protection for the molten metal from oxidation, the combining monoxide and hydrogen having a greater affinity for oxygen than the metal.

31 In the use of the torch it is very important to maintain a neutral flame, that is, one having neither an excess of acetylene nor of oxygen, as the first would carbonize the work and the second oxidize it. The proper condition of the flame is easily determined by observation, and the gases can be regulated accordingly. With an excess of acetylene there will be two inner cones, one extending beyond the other and less luminous. By reducing the acetylene pressure the second cone will recede and when it finally coincides with the first, or disappears, the flame is neutral. When the adjustment is exact the inner cone will have a sharply defined contour and a slightly rounded point. With an excess of oxygen the flame has a violet cast and the end of the inner cone is feathery. Excess of either gas can also be detected by the appearance of the work. If the flame is carbonizing the metal will glow intensely, and if oxidizing the metal will boil.

ACETYLENE GENERATION

32 All methods of acetylene generation are alike in the materials used, calcium carbide and water. While any carbide could be used, the calcium form is the only one obtainable on the market in large quantities and at a reasonable figure. It is a product of the electric furnace, being formed only at a very high temperature from a mixture of ground coke and lime in the proportions of 9 to 14 by weight. The reaction is $CaO+3C=CaC_2+CO$.

33 When calcium carbide and water are brought together acetylene is evolved with slaked lime as a residue expressed by the following equation: $CaC_2+2H_2O=Ca(OH)_2+C_2H_2$.

34 Commercial carbide yields from $4\frac{1}{2}$ to 5 cu. ft. of acetylene per lb. Lump carbide in sizes of $1\frac{3}{4}$ x $\frac{3}{8}$ in., known as "nut," is claimed to yield from 5 to 15 per cent more acetylene than finely divided

carbide, probably due to more or less slaking of the latter by moisture in the air. For that reason generators capable of using the lump carbide claim a certain advantage over those limited to the use of the crushed form.

35 Two kinds of generators are used known from their manner of feeding as water-feed or "water-to-carbide" generators and carbide-feed or "carbide-to-water" generators. The first is very little used because of the disadvantage that the apparatus gets very hot and the gas is not likely to be so good. This is due to the tendency of the gas to become overheated and to some extent to be converted into oily matters, an effect known as polymerization. Where this has occurred it is indicated by a yellowish or brownish staining of the residue. It can be avoided where care is taken properly to water-cool the apparatus.

36 An example of the most approved apparatus of this type is that recently installed in the Santa Fé shops at Topeka. It consists of cylindrical iron cells placed horizontally, each fitted with galvanized iron drawers of six sections for holding carbide. The water is admitted to each of the end sections and the gas generated is carried away in pipes. When the carbide becomes exhausted in the end cell, sufficient water has accumulated to run through a V-shaped opening in the partition to the next section, after which the drawer is withdrawn and recharged. As a cell is opened the water supply to it is automatically cut off. These generating cells are kept submerged in running water to keep the temperature of the gas as low as possible. Any cell can be inspected or recharged without interfering with the operation of the others. The gas is further cooled and washed by being passed through water before it reaches the holder.

37 Where the reverse manner of feeding is used and the carbide is dropped into the water, the gas is washed as it is evolved and it and the apparatus kept cool. In these generators it is well also to have an abundant supply of water in the bottom. The generally accepted rule now is a gallon of water to each pound of carbide.

38 The carbide-feed machines may again be divided into two classes, gravity feed, where some sort of a valve is used to release the carbide, and forced feed, where usually by means of clock work the carbide is forced off a plate or some similar device. In both types the action of the feed is dependent upon the pressure of gas within the machine. As it falls more carbide is dropped into the water and as the pressure rises the feeding is arrested. Both generate acetylene at sufficient pressure to be used directly in the pressure or positive-

mixture types of torches. A necessary feature of all types of generator is a water-sealed flash-back chamber or its equivalent to make communication of the flame to the generator impossible. Safety devices interlock the various movements of valves operated when recharging the machines. All in all it would seem that aside from inexcusable carelessness any generator approved by the National Board of Fire Underwriters can be installed and used without danger to life or property.

39 Low-pressure generators such as are used for lighting are suitable for supplying torches of the injector type. Their principal difference from the types just referred to lies in the feed control, which is usually by a bell instead of a pressure diaphragm.

40 Where a generator is carried on a portable outfit the water-to-carbide type is probably the safest, since a carbide-feed type would be more likely to generate gas when jarred. Some argue that a generator should never be carried on a portable outfit, but that compressed gas tanks should be used. This calls for the explanation that whenever compressed acetylene is spoken of what is meant is dissolved acetylene, for the gas becomes very explosive when compressed to above two atmospheres. In 1896, Claude and Hesse, two French engineers, discovered that acetone is a remarkable solvent for acetylene. For each atmosphere of pressure it will dissolve 25 times its own volume of acetylene, and in this condition the latter is not explosive under heavy pressure. The acetone is placed in tanks containing porous material so that there are no spaces for the gas to separate and collect in, and the acetylene is compressed into them. Acetylene in this form, although costing twice as much as when generated, is very convenient in outside repair work where portability is a feature.

41 Of all hydrocarbons, with the possible exception of liquid and Blau gas, acetylene possesses the greatest proportion of carbon, 92.3 per cent, the remaining 7.7 per cent being hydrogen. It is therefore most nearly gaseous carbon, for there is no known means of obtaining a high enough temperature to gasify pure carbon. It gives about five times as much heat per cubic foot as hydrogen and a flame of greater intensity, the temperature being, as has been mentioned before, 6300 deg. fahr.

OXYGEN GENERATION

42 Oxygen generation is of three classes, chemical, electrolytic and atmospheric, to each of which except the second there are subdivisions.

43 Chemical oxygen production is of two kinds, wet and dry, and of each there are several variations. The wet process at the Santa Fé shops consists of boiling in a water-tight tank, a saturated solution of bleaching powder, or calcium oxychloride, to which is added at regular intervals a saturated solution of 5 parts iron sulphate and one part copper sulphate. A mechanically operated paddle, agitating the mixture, facilitates the release of the gas. The oxygen passes off at the top and the residuum remains in solution to be drawn off before the tank is discharged. The water in the tank is heated by the exhaust steam from the oxygen compressor. From the generator the oxygen is passed to a water scrubber to remove the chlorine and foreign matter, and for a final cleaning the gas is passed through a second scrubber containing a solution of caustic soda, which also serves as a water seal to the gasometer to which the clean gas is delivered, and from which it is drawn by the compressor and stored in tanks at a pressure of 85 lb.

44 The Lavoisite process is another of the same class, which, however, evolves oxygen directly under pressure by the simple addition of hot water to a powder of secret composition. The Sowers Manufacturing Company, which introduced it, recently sold the rights to the Davis-Bournonville Company. The Lavoisite powder is received in a drum which is inverted over the top of the generator and connected with it by means of a special valve arrangement in connection with the cover of the drum. The contents of the drum are discharged into the generator, the drum removed and the generator manhole cover replaced and screwed down. Hot water is then pumped into the generator until the charge is exhausted, the oxygen in the meantime passing through a scrubber to the distributing main or storage tanks. When the generation is complete the hot water is shut off and cold water pumped in until all of the gas remaining in the generator is displaced. When the generator is clear it is ready for a new charge.

45 Still another wet process used a powder sold under the trade name of Epurite, a mixture consisting of 20 parts chlorate of lime, one part sulphate of copper and three parts sulphate of iron, which when brought into contact with water evolved oxygen. One pound of the material produced about 8 cu. ft. of oxygen. The generating apparatus deteriorated so rapidly and the cleaning of it was so mussy that it was soon abandoned.

46 The most common chemical process is the dry evolution of oxygen under the influence of heat from a mixture of 100 parts by

weight of crystallized chlorate of potash and 13 parts of manganese dioxide, contained in a sealed retort. The gas requires thorough washing in a solution of caustic soda to eliminate its chlorine. It can be compressed after washing in a two-stage compressor, which is the practice in one of the Davis-Bournonville oxygen plants, or generated under pressure by using heavier retorts and heating longer or more intensely. The Oxi-Carbi Company, the Henderson-Willis Welding & Cutting Company and others furnish equipment of the latter type, as well as the Delcampe Welding Company which gives the name Oxivite to the mixture used, which is claimed to give off no chlorine.

47 A somewhat similar process is that using oxygenite, the trade name for a mixture of perchlorate of potash with infusorial earth and charcoal. When ignited in a closed retort it burns, evolving an excess of oxygen over that required for its own combustion. The reaction under the influence of heat is $KClO_4 = KCl + 2O$. The necessary pressure is obtained without subsequent compression.

48 The fault with most chemical processes is the difficulty of eliminating the poisonous chlorine, which also has a tendency to impair the weld. With all processes using manganese dioxide precautions are necessary for obtaining pure oxide, as carbon or hydrocarbons in any form, even traces of oil from a compressor which should therefore not have cylinder lubrication, must be eliminated before compressing the oxygen on account of their combustibility.

49 The purer the oxygen the better, as even small percentages of impurities decrease the economy and the strength of the welds. Oxygen produced by the electrolytic process is 99 per cent pure, the only impurity being a trace of hydrogen. The electrolytic process of the American Oxyhydric Company has already been referred to, and the principle in all is alike. Apparatus for this process is also made by the International Oxygen Company and the Davis-Bournonville Company.

50 The International Oxygen Company's system makes use of a group of oxy-hydrogen generators, each an electrolytic cell through which, by the passing of an electric current, water containing some alkali is decomposed. The oxygen collects at the positive electrode and the hydrogen at the negative electrode, which is the iron tank containing the solution. The positive electrode is a perforated tank surrounded with an asbestos sack. The two gases as they collect on their respective electrodes are effectively separated, and the bubbles

rising as they collect are entrapped in compartments at the top, separated from one another by a water seal.

51 Atmospheric oxygen is next in purity to electrolytic, its only impurity being nitrogen. The process used by the Linde Air Products Company at its various works from which it distributes for sale the gas compressed in tanks, consists first in the complete liquefaction of the air to be resolved by a process of accumulative cooling. The liquid thus formed is then submitted to a process of rectification at the same time that an almost complete transference of heat is obtained from the compressed air entering the apparatus to the liquid air thus formed. In this way 95 or 96 per cent pure oxygen can be obtained. Air is compressed by a four-stage compressor with practically adiabatic compression, and after each stage the heat of compression is removed by passing the air through a cooler, through which water is circulated. The carbon dioxide and moisture in the air are readily eliminated by freezing and the oxygen becomes liquid while the nitrogen is still gaseous. This explains in brief the principle of the separation without going further into the details of the apparatus. The equipment is in duplicate to permit continuous working, so that when ice, due to entrapped moisture, has accumulated in one the other can be put in operation while the first is alowed to thaw.

52 Another atmospheric process, partly chemical, employs barium oxide first to absorb and then liberate oxygen. With a constant pressure barium oxide will absorb oxygen from the air to form the peroxide at a temperature of 600 deg. cent. and at 850 deg. cent. will again give off the excess oxygen. With a constant temperature of 700 deg. cent. the same effects can be accomplished by varying the pressure, the peroxide being formed at $1\frac{3}{4}$ atmospheres and the excess oxygen liberated by diminishing the pressure.

PRESSURE REGULATION

53 An important device between the torch and the source of the gas, whether oxygen, acetylene or hydrogen, and whether from pipe line, generator or tank, is the pressure regulator, for with all torches it is necessary to maintain constant pressures to secure uniform work. Regulators vary somewhat according to the gas, and in minor details in different makes. The function of the regulator is that of a reducing valve to maintain any set constant pressure not exceeding that of the source, and there is always combined with it a pressure gage on the discharge side to show the pressure admitted to the torch.

Where the gas is taken from portable cylinders an additional gage is provided on the other side of the regulator to show the state of depletion of the compressed gas in the cylinder.

USE OF THE TORCH

54 The rest of this paper applies practically to all kinds of gas torches, and especially to the oxy-acetylene and oxy-hydrogen torches, unless an exception is noted.

55 The utility of all torches lies in their ability on account of the high temperatures of their flames, to bring the part of the metal acted upon to molten condition before the heat supplied can be dissipated by conduction and radiation, therefore making possible local recasting. Some heat is of course lost, but probably not without an advantage in reducing trouble from expansion and contraction.

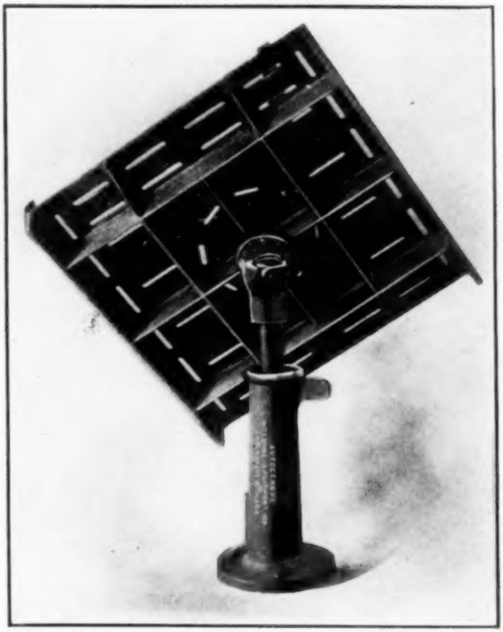

Fig. 11 Welding Table

56 The envelope of the flame starts the heating of the metal in advance of the actual work and the local heat at the point of the inner cone follows. Metal, thicker than $\frac{1}{8}$ in., to be joined should be scarfed or chamfered to give a V-groove in which to work, permitting

penetration of the flame to the bottom of the joint. It is usually necessary, except on thin sheets not scarfed, to add metal to the joint. This is melted in from a wire or strip generally of the same material as those being joined, which is called a soldering or welding stick. In making the weld, after the metal adjoining the joint is itself in running condition, molten metal is added drop by drop from the stick until the groove is filled, and where it is allowable a little excess is built on to make the joint fully as strong as the rest of the work. If the metals joined are dissimilar, a stick of approximately the same material as that of the two being joined which melts at the

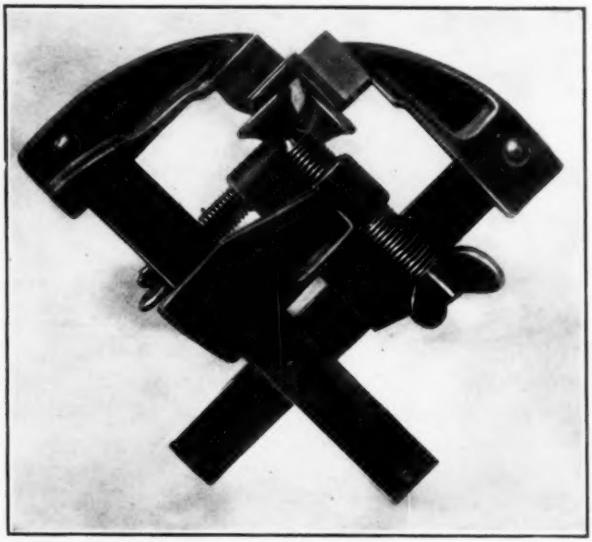

FIG. 12 CLAMPING ARRANGEMENT FOR WELDING TWO THIN PIECES

lower temperature should be used. Otherwise the added metal will chill when falling upon the other molten metal. Scaling powders are sometimes used for welding cast iron and aluminum, but less so than formerly since experience has shown them to be seldom necessary. The function of a scaling powder is not primarily that of a flux to prevent oxidation, but to remove any scale in the weld and make the metal more fluid. With proper manipulation of the torch, which is now better understood, scale is not so apt to be formed in the first place.

57 A torch or nozzle is selected which will give a size of flame suitable for the work in hand, which must be large enough to do the work

thoroughly in the shortest time without consuming unnecessarily large quantities of the gases. With the proper blowpipe flame the heat is kept local so that expansion and contraction influences are minimized. It is not good practice to hold or grip anything to be welded so that it cannot adjust itself for expansion and contraction. Therefore, long seams, longitudinal or circumferential, should be first spot-welded or tacked at intervals of 6 to 12 in., and after tacking all bands should be removed. Castings to be welded should be preheated all over if there is any chance of having contraction strains produced when the weld cools. The preheating should not go above 500 deg. fahr. if there is any serious consequence from permanently distorting the casting. The preheating, usually done in a forge, or a coke fire, or by a gas-air blowpipe, saves the corresponding application of heat with the torch using more expensive gases, and also

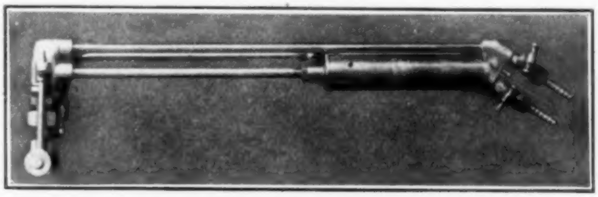

Fig. 13 Cutting Torch Showing Torch-Guiding Device

saves the latter when the welding is being done, by reducing the loss of heat by conduction and radiation.

58 The welding of aluminum is something of an art in itself. This metal does not behave like any other. It first becomes pasty when heat is applied and does not become fluid until very near the burning point. It is quite common to facilitate the uniting of the metal by working it with an iron spatula until the joining parts amalgamate. Fluxes are often used for aluminum welding, the functions of which are to reduce the invisible oxide film always present on the surface of metallic aluminum, so that the parts flow together, and to protect the hot metal from the air and further oxidation.

59 Very thin metals are most easily welded when the weld is performed on the edges turned up as flanges back to back, but this is not necessary and those expert at the work can now butt-weld thin sections without even adding metal from a stick. Most depends on moving the torch steadily at the proper speed, for it is very easy to let the torch dwell too long at one spot and burn a hole through so that metal has to be added and a less neat joint results.

60 In all welding judgment plays a large part, and a knowledge of metals and their characteristics is a great help. It is a nice determination, for example, as to just how far on each side of the joint to carry the heating, since an error either way is likely to produce a poor weld. Expansion and contraction must always be taken into consideration, otherwise internal strains will occur, which are likely to produce a new crack when the metal cools. Preheating, as before explained, removes most of the difficulty.

61 As to the strength of welds, much depends upon the operator. Welded steel work can easily compare with double riveting and

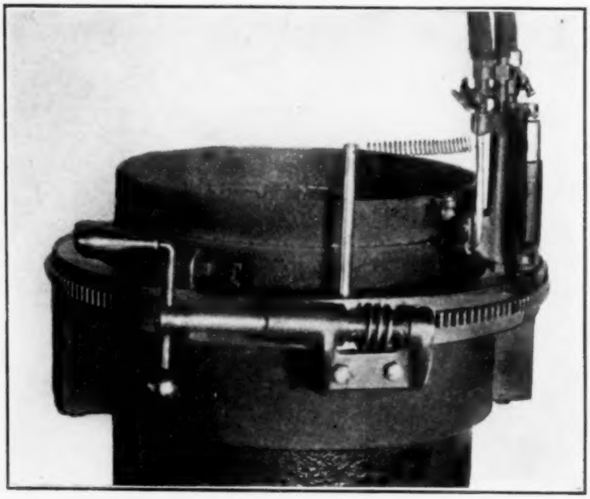

Fig. 14 Torch-Guiding Device for Circumferential Cutting

calking and in some cases can attain the strength of the butt strap joint.

62 With flame welding nearly all kinds of metals can be welded, cast or wrought iron, steel, brass, aluminum, copper, etc. Skill and experience count for much and many things originally thought impossible are now being quite readily accomplished. A consistent study of materials and their composition and structure has led to the overcoming of many difficulties. The behavior of metals under the influence of heat, particularly their expansion and contraction, requires study and allowances in making welds. Not a little progress has already been made in the heat treatment of welds after they are

made to restore largely the original properties as to structure and strength.

63 The flame processes are especially valuable in the welding of metal from No. 20 gage up to $\frac{5}{8}$ in. thick. Work that has to withstand high heat, such as boilers, annealing boxes, etc., can be satisfactorily welded, and it is probable that this method will more and more take the place of riveting, particularly since in many cases it is

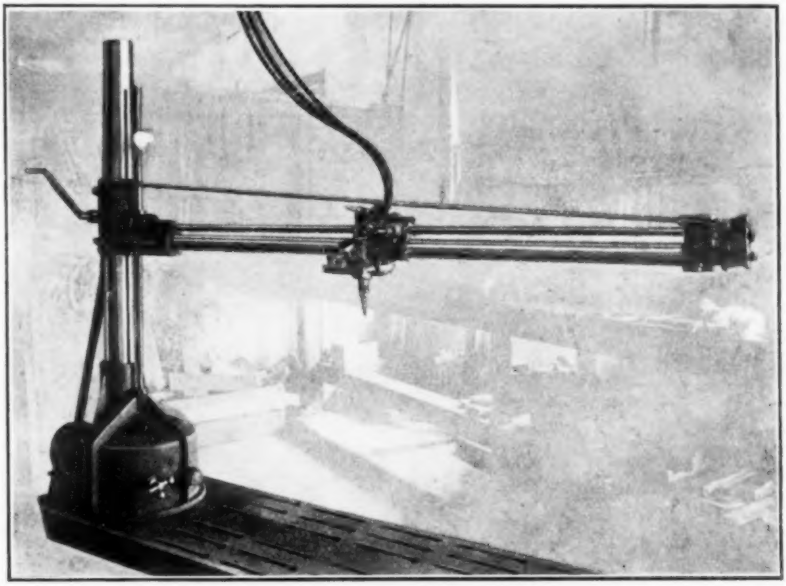

Fig. 15 Torch-Guiding Machine Capable of Swivelling to Various Angles

cheaper. All kinds of tanks, especially those designed to contain anything that would tend to eat its way around rivets, are better for being welded.

64 It is apart from the purpose of this paper to go into an extensive enumeration of the specific kinds of construction and repair work possible by arc and flame welding. No list would be long complete, for new applications are continually being found, and the more usual ones are already familiar to all. Among the things that are still difficult or impossible are the welding of very heavy sections, this being better left to thermit welding, flame welding being generally too expensive and the greater pressures of the gases necessary

to secure deep penetration being likely to produce crystallization of the work structure; brazed and galvanized articles, on account of the volatilization of the zinc, producing porous spots; and the welding of aluminum to other metals.

ARC AND FLAME CUTTING

65 Although the welding, and not the cutting of metals, is our subject, it would hardly be proper in a discussion of arc and flame welding to make no reference to the scarcely less important function of the same implements used in the cutting of steel and wrought iron. These are the only metals that can be so cut, some alloy steels being

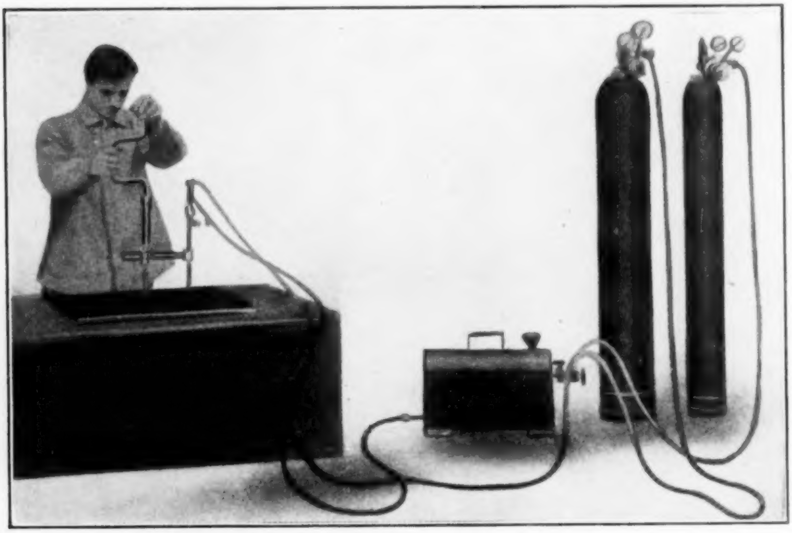

Fig. 16 Arrangement for Cutting Holes and Circles

excepted. The torches using hydrogen have the advantage in the cutting of heavy sections, being able to cut to a greater depth on account of the greater penetration. With such torches cuts have been made in metal 24 in. thick, while 12 to 15 in. is the limit that has been accomplished with the oxy-acetylene torch.

66 For cutting, the torch has an additional jet of oxygen under higher pressure, up to 125 to 225 lb. The acetylene or hydrogen and low-pressure oxygen preheat the work, and the high-pressure jet following in the wake of the heating flame does the actual cutting by producing a very high rate of oxidation. Part of the metal is removed

as iron oxide and the heat of the combustion melts the rest so that it runs out of the cut.

67 Reference to the time and cost of doing work by any of the various processes is purposely omitted here since so many variables enter into such considerations, that any figures that might be given would probably be more misleading than instructive. Both are matters that can be determined only by experimentation under the conditions that will apply, and a result in one field can never be taken as a criterion for another.

MACHINE WELDING

68 A very large field for ingenuity has been opened in connection

Fig. 17 Pipe-Cutting Machine

with all of the welding processes, in the devising of means for the mechanical guiding of the welding or cutting implements, or otherwise facilitating the operations. Most of this work has been done naturally by the users of the apparatus, particularly where the work they have to do is largely in duplicate. Unfortunately these are seldom made public, either because the user has no inclination to enter into the manufacture and marketing of them, or because he does not wish his competitors to have the advantage of their use that he enjoys.

69 As indicating the scope of a few, illustrations are here included of devices or machines that can be purchased by any user.

70 Fig. 11 shows a welding table made by the Autogenous Welding Equipment Company. developed first for its own use and found so useful that it is now marketed. The work is strapped to it and can then be revolved or tilted to any position so that any part can be brought where it is most easily reached by the torch. The table can also be raised or lowered to suit the convenience of the operator.

71 Figs. 12 to 15 are Davis-Bournonville devices. Fig. 12 is a clamping arrangement for holding two thin pieces to be welded on their edges at right angles. One of the simplest of torch-guiding devices is the provision of rollers attached to the head of the torch as in Fig. 13. This happens to be a cutting torch and the rollers serve

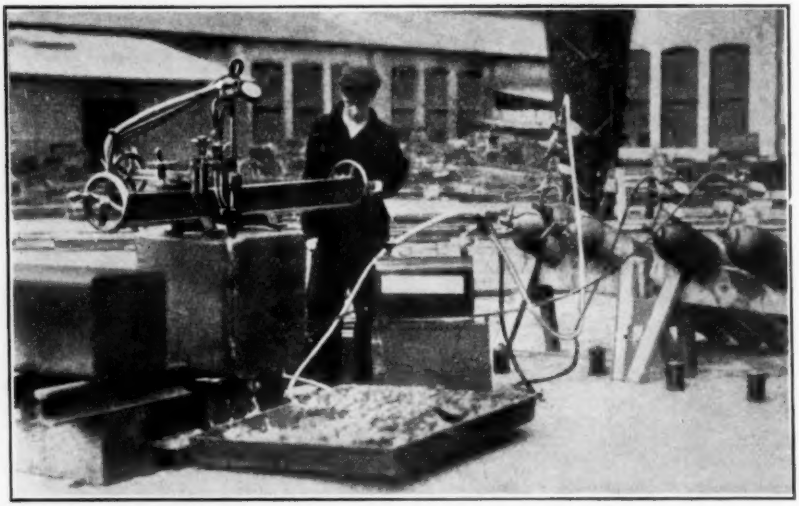

FIG. 18 PLATE-CUTTING MACHINE FINISHING THE CUT OF A 24-IN. STEEL BILLET

to hold the tip at the proper distance from the work. The American Oxyhydric Company has a similar arrangement. For circumferential cutting of pipes a torch guiding device is shown in Fig. 14. A more pretentious machine is that shown in Fig. 15, which will be seen to resemble a radial drill with a torch carried on the movable head where we are accustomed to see the drilling bit. It gives adjustability in all directions and a regulatable movement parallel to the arm or the column. The torch can also be swivelled to various angles. The remaining illustrations are of American oxyhydric devices. Fig. 16 is a simple arrangement for cutting holes and circles,

and a device is also made for cutting regular or irregular curves. Another form of pipe-cutting machine is shown in Fig. 17. Fig. 18 shows a plate-cutting machine finishing the cut of a 24-in. steel billet.

72 Attention is just beginning to be given to mechanical means for guiding the torches when doing welding and cutting. For neat uniform work of both kinds they are practically imperative, and save greatly in time that would otherwise be necessary to do careful work. With a cutting torch mechanically guided and moved at a uniform rate, circular or straight cuts can be made giving as smooth an edge as though cut by a saw or any other tool. Especially for thin sheet welding machines are desirable because of the precision with which the torch can be moved.

THERMIT WELDING

By G. E. Pellissier, New York

Associate Member of the Society

73 The compound to which the trade name thermit has been given consists of finely powdered aluminum and oxide of iron combined in such proportions and in such a manner as to react when ignited in accordance with the formula, $Fe_2O_3 + 2AL = AL_2O_3 + 2Fe$. This compound has the peculiar property that when ignited in one spot combustion proceeds throughout the entire mass without any

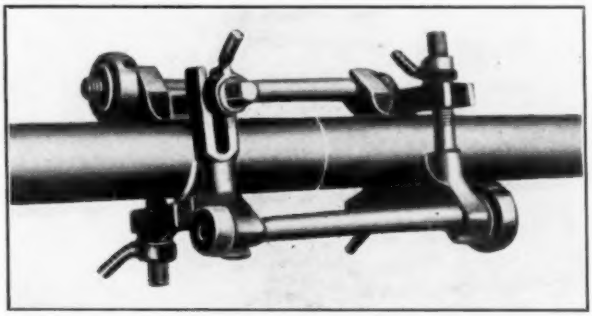

Fig. 19 Pipe Welding. Pipe held in Clamps

supply of external heat, the aluminum reducing the oxide of iron practically to pure metallic iron and combining with the oxygen to form aluminum oxide or corundum. As the reaction is exothermic, an intense heat is generated, the temperature of the molten mass being estimated at about 5400 deg. fahr.

74 It is also of interest to note that the compound is not combustible in the ordinary sense of the word, as it can be placed upon molten iron without igniting.

75 In practice the reaction of the mass is started by a special ignition powder which creates an intense temperature at one spot, whence the reaction proceeds of itself without any further supply of

heat, requiring less than one minute for completion, regardless of the amount of the compound brought into reaction.

76 As before stated, the product of the reaction is aluminum oxide and metallic iron, the proportion being approximately 50 per cent of each by weight, but as aluminum will act similarly on the oxides of nearly all of the metals used in making steel, it is necessary

Fig. 20 Pipe Welding in Trench. Pouring Thermit Slag and Steel in Mold

only to mix these oxides with the iron oxides in correct proportions in order to obtain practically any steel that is desired.

77 In applying this reaction to the problem of welding, two quite distinct methods are followed, one of which utilizes the heat of the reaction to bring the pieces to be united to a welding temperature, whence they are forced together by suitable clamps and butt-welded in a manner similar to forge-welding. In the other, the ends of the pieces to be united are fused or melted together by the molten metal from the reaction, which amalgamates with them into a molten mass,

which is retained by a suitable mold and allowed to cool, thus uniting the parts into one homogeneous mass.

78 The first method, which is commonly designated as butt-welding, is applied chiefly to welding pipes, tubes and small rods.

79 In making a weld by this method the ends of the pipe to be united are filled or machined to fit closely together, then fastened to-

Fig. 21 Pipe Line Welded by Thermit Process for Department of Agriculture, Washington, D. C. View taken during Test. Pipes covered by Frost from Contained Ammonia

gether with suitable clamps, Fig. 19, and surrounded with a cast-iron mold designed to hold just enough of the molten mass to bring the parts to be united to a welding heat. The necessary amount of thermit is then ignited in a small flat-bottom crucible, and as soon as the reaction is over the contents of the crucible are poured into the mold, Fig. 20. The aluminum oxide having risen to the top of the crucible, on account of its low specific gravity, flows into the molds first, and coming in contact with the cold iron adheres to it, forming a thin refractory coating which prevents the molten steel, which

flows in later, from adhering either to the mold or the parts to be welded. As soon as the molten mass has been in the mold long enough to allow the heat to penetrate the parts to be welded, a length of time determined by experiment, the pieces are forced together by the clamps, which completes the weld. On account of the fact that pieces thus welded are heated out of contact with the air, no oxidation can take place and consequently no flux is necessary, care being taken simply to see that the parts to be united are clean and bright.

FIG. 22 WELD ON STERN FRAME OF STEAMSHIP "CORRUNA" BELONGING TO CANADIAN LAKE NAVIGATION COMPANY. WELD EXECUTED IN MONTREAL, 1907

80 Rods up to 2 in. in diameter and all sizes of pipes from 1 in. to 6 in. in diameter, standard, extra heavy and double extra heavy, have been welded by this method.

81 The chief application of this process is in welding ammonia, compressed air, high-pressure steam and hydraulic lines, where the work has to be done in place, Fig. 21. As the outfit required for welding 4-in. pipes weighs less than 100 lb. and can be manipulated in a trench wide enough for a man to stand in, lines can be welded which would otherwise have to be provided with mechanical joints.

82 As an illustration of the efficiency of welds made in this manner, it may be noted that a hydraulic pipe line, 4-in. extra heavy, welded for the New York Central Railroad at Albany, was subjected to a test pressure of 3000 lb. per sq. in. maintained for 24 hours, and

has been operating for two years under a working pressure of 1500 lb. per sq. in. with entire satisfaction. Physical tests on welded samples before the contract was awarded showed the strength of the welded section to average from 80 to 90 per cent of the strength of the pipe in tension and cross bending.

83 In welding by the second method, the so-called intermediate welding, the parts to be united are not brought close together nor fitted in any way, but instead a space varying with the section to be united from ½ in. to 2 in. in width is provided to allow a free flow of

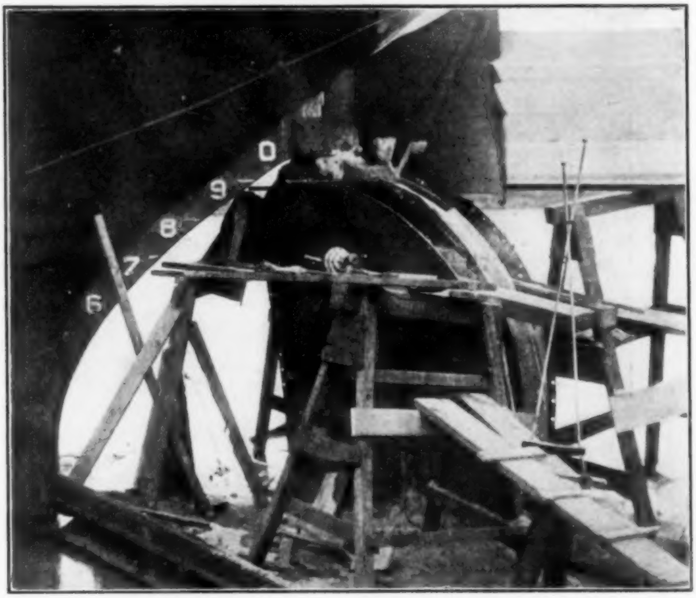

Fig. 23 Rudder Frame of Steamship "Duluth" showing Materials in Position for Welding. Repair executed without placing Vessel in Drydock

the molten thermit metal between the ends. After the parts have been thoroughly cleaned of grease, dust, etc., they are surrounded with a refractory mold very similar to that used in making steel castings. This mold is provided with a suitable pouring gate and riser, and in addition to this a gate or opening at the lowest part of the mold used for preheating.

84 If the parts to be welded are of a uniform section these molds are made from wooden patterns similar to standard foundry practice; but where the parts to be united are of an irregular section which

would involve difficult and expensive pattern work, such as in repair work, the so-called wax method is used. In this method the space between the parts to be united is filled with wax and a reinforcing collar of any desired dimensions is formed of the same material. As soon as the wax is hard the parts are surrounded with a mold box and the mold rammed in place, wooden patterns being used for gates and risers. Heat is then applied through the preheating gate at the lowest part of the mold, which melts the wax, allowing it to

Fig. 24 Two Welds on Flywheel executed for Consolidated Nickel Company, Sylva, N. C. This Flywheel was 24 Ft. in Diameter and Welded Segment weighed 10 Tons

flow out and leaving a cavity in the mold of the exact dimensions desired. The preheating is then continued until the mold is thoroughly dried and the ends of the pieces to be welded are brought to a bright red heat. While the preheating is going on, a so-called automatic crucible, having a small opening in the bottom with arrangements for pouring and tapping, is placed over the heating gate of the mold, into which are poured the thermit and additions.

85 The amount of thermit necessary to fill the mold is obtained by weighing the wax used and multiplying the weight by 32. This is obtained by multiplying the weight of wax by the ratio of specific gravity of wax to that of iron, approximately, then by 2, as thermit is half iron, and again by 2 to provide for metal in the riser. To the thermit is added the proper amount of carbon steel punchings, nickel chromium, manganese, etc., to give the resulting steel approximately the same analysis as the pieces to be welded. These alloys can be

added in the form of shot or as manganese thermit, chromium thermit, etc.

86 In making welds in this manner the usual precautions have to be taken to provide for the contraction of the metal when cooling whenever possible. Welds can of course be made where it is impossible to provide for such contraction, but the welds will then be

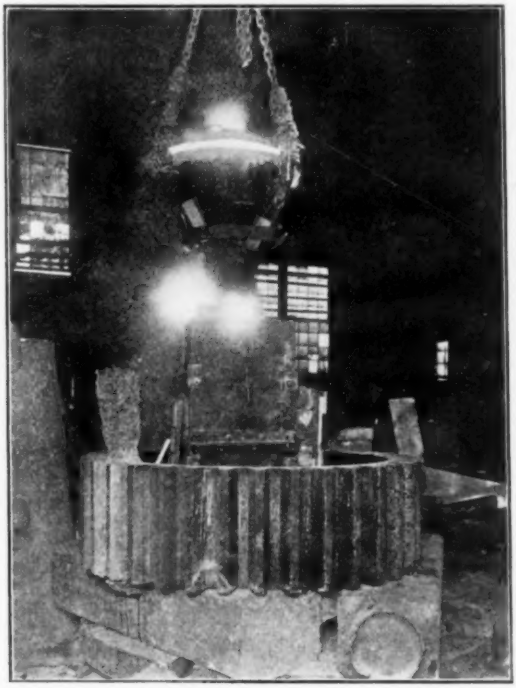

FIG. 25 GEAR WHEEL WELDED IN TWO PLACES. VIEW SHOWS ONE COMPLETED WELD AND THERMIT STEEL FLOWING IN THE MOLD FOR SECOND WELD

subjected to the internal stresses due to cooling. This method of welding has its chief application in welding rails for street railway companies and in repairing all kinds of machinery where the sections to be welded are large, and where the work of necessity has to be done rapidly or in place. Among such repairs might be mentioned the welding of engine frames, crankshafts, stern and rudder posts of vessels, flywheels, and large castings of every description.

87 A brief description of a few representative repairs will serve to illustrate what may be accomplished by this method of welding.

88 In getting away from her pier in the Lachine Canal, the "Corrunna," a vessel of 1296 tons registered, 35 ft. beam and 21 ft. depth, was caught by the current and swung against the walls of the canal, the skeg being broken off close to the keel and the rudder post 10 in. above the top of the rudder.

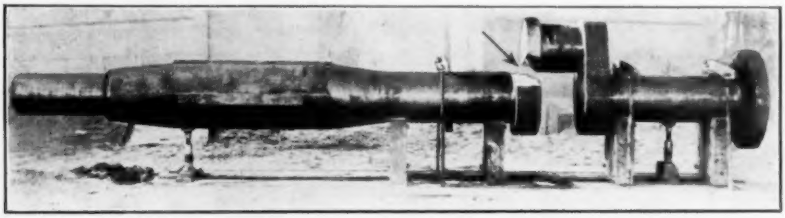

Fig. 26 Fracture in 14-In. Crankshaft of Binghamton Railway Company, Binghamton, N. Y., Cut Out for Thermit Repair

89 As there were no facilities in Montreal for making a repair of this nature, it would have been necessary to tow the vessel to Cleveland. Both of these welds were made in five working days without removing the stern frame. Fig. 22 gives a clear idea of the character of the work.

Fig. 27 Finished Weld of Binghamton Crankshaft showing Metal left in Pouring Gates and Riser. Surplus Metal removed before placing Shaft in Service

90 The steamship "Duluth," which is 404 ft. long, 50 ft. beam, and 6400 tons registered, had its rudder frame broken 10 in. aft of the rudder post, the section to be welded being $2\frac{1}{2}$ in. by $9\frac{1}{2}$ in. The work of welding was carried on without docking, rafts made fast to the vessel (see Fig. 23), and required only two days for completion.

91 A flywheel, weighing 48 tons, was wrecked at Sylva, N. C.,

when the car upon which it was being transported overturned. The wheel, which was 24 ft. in diameter, 74 in. face and weighed 48 tons, was cast in four pieces. The piece wrecked was broken through the rim, the section of the fracture being about $3\frac{1}{2}$ in. by 37 in., with ribs at the edges $3\frac{1}{2}$ in. by 6 in., and one of the spokes was broken near the hub and near the rim, sections at fractures being about 8 in. by 11 in. elliptical. The part repaired is shown in Fig. 24. The repair was made in the wilderness where the wreck occurred, the nearest

FIG. 28 TWO FINISHED THERMIT WELDS ON A LOCOMOTIVE FRAME. REPAIR BEING EXECUTED WITH VERY LITTLE DISMANTLING OF THE LOCOMOTIVE

machine shop and source of supplies being 50 miles away. The flywheel has been in continuous service over two years under severe conditions, as the 750-h.p. engine and generator of which it is a part are frequently subjected to a 50 per cent instantaneous overload.

92 A steel gear driving a so-called continuous rolling mill at the works of the American Tool and Stamping Company, at Bridgeport, Conn., was broken in two places. The gear is 6 ft. in diameter with a 22 in. face. The time required for making these two repairs complete was 46 hours. Fig. 25 shows one of the welds repaired and the other being poured.

93 The main driving shaft of the 750-h.p. engine and generator

at the Binghamton Railway Light and Power Company, Binghamton, N. Y., was 15 ft. long over all and varied in diameter from 10 in. to 16 in. The crank webs, one of which was broken in two places, as shown in Fig. 26, are 28 in. by 18 in. by $6\frac{1}{2}$ in. The work of welding was not done in place in this instance but at the shops of the Goldschmidt Thermit Company, as it was impossible to align the shaft properly in the power station. The welding completed ready to remove the risers is shown in Fig. 27. The operation required three days.

94 Fig. 28 shows an interesting repair to a locomotive frame, and many other illustrations might be given of the practical application of this method of welding, multiplying many times those already shown.

TABLE 2 BENDING TESTS

Description	Size of Bar, In. Diameter	Span, Ft.	Total Load, Tons	Angle Bent Through	Effects
Solid bar	2	15	10.18	180	Uncracked
Thermit welded bar, bulb turned off	2	15	10.09	46	Broken at weld
Thermit welded bar, bulb left on	2	15	17.30	125	Bent as far as practicable. Uncracked

TABLE 3 TENSION TEST

RIEHLE BROTHERS TESTING MACHINE CO., INC., PHILADELPHIA, APRIL 7, 1908

Size, In.	Area, Sq. In.	Elastic Limit, Lb.	Elastic Limit per Sq. In., Lb.	Ultimate Strain in Lb.	Ultimate Strain per Sq. In., Lb.
749	0 441	18670	42330	27930	63330

95 As regards the efficiency of welds made in this manner, the physical tests and chemical analyses in Tables 2 to 4 show clearly that the metal of the weld is practically equal in strength to the metal of the parts repaired, except possibly in the case of special steel alloys. When it is considered, however, that the section at the fracture can be increased to any desired dimension when the repair is made, it will be readily seen that the repaired section can be made stronger than it was originally.

96 The section tested in tension was taken from a weld on a section 6 in. by 8 in. and was turned from the thermit metal and not subjected to annealing or forging.

97 Table 4, giving the chemical analyses of welds made on carbon

steel and carbon steel containing nickel, illustrates how closely the material of the weld approaches that of the metal welded.

TABLE 4 CHEMICAL ANALYSES OF WELDS

	Nickel Steel					Carbon Steel			
	C	M	S	P	N	C	M	S	P
Steel	0.92	0.76	0.029	0.018	1.06	0.55	0.89	0.068	0.09
Weld	0.36	1.21	0.019	0.036	1.11	0.48	0.90	0.032	0.063

98 The process of welding is invaluable for all kinds of repair work, not only because by welding broken parts the pieces themselves can be made as good as new, thus saving the original cost, but on account of the extreme portability of the outfit and because in nearly all cases the welding can be accomplished on the spot, thus saving a great deal of time and keeping a plant or ship in operation when it would otherwise have to be put out of commission for days, weeks, and sometimes months.

ARC WELDING

By C. B. Auell,[1] East Pittsburgh, Pa.

Non-Member

99 Welding through the medium of the electric arc may be accomplished by any of three different processes, named respectively after the inventors, Benardos, Slavianoff and Zerener. Like oxy-acetylene and oxy-hydrogen welding, all of these are very properly classed as autogenous welding processes, since fusion is accomplished without pressure, simply by allowing the metals to melt, then to mix and unite as they cool. The essential difference between the processes under discussion may be briefly indicated as follows:

Benardos Process. Arc drawn between the metal to be welded which forms one terminal of an electric circuit and a carbon electrode which forms the other terminal.

Slavianoff Process. Arc drawn between the metal to be welded which forms one terminal of an electric circuit and a metal electrode which forms the other terminal.

Zerener Process. Arc drawn between two carbon electrodes, the metal to be welded being placed in contact with the arc.

BENARDOS PROCESS

100 The Benardos process is due to Benardos and Olzewski, to whom a United States patent was granted in 1887. From this date it will be noted that the term of the patent has now expired and anyone is therefore at liberty to make use of it.

APPARATUS REQUIRED

101 A complete outfit for this process of welding includes a suitable source of direct current supply, controlling apparatus for the regulation of current and voltage, carbon electrodes, a suitable enclosure for the work, a protective covering for the operator, fire-clay or other material for molding purposes, filler and flux. Fig. 29 is a diagrammatic sketch of the electric apparatus as it is perhaps most commonly used. Starting from the generator, one branch of the circuit leads through an ammeter and a circuit-breaker direct to the carbon electrode, which usually forms the negative terminal; the

[1] Asst. Mgr. of Wks., Westinghouse Elec. & Mfg. Co.

other branch of the circuit leads from the generator, through a single-pole switch, to the main rheostat, then to the metal to be welded which, either directly or indirectly through a metal table, forms the other terminal. There are, of course, modifications of this general scheme, each of which possesses one or more features of merit, but the limits of this paper preclude their being discussed in detail.

CURRENT SUPPLY

102 The current, which must always be direct, may be obtained in any of several ways: (*a*) from an independent generator, shunt or

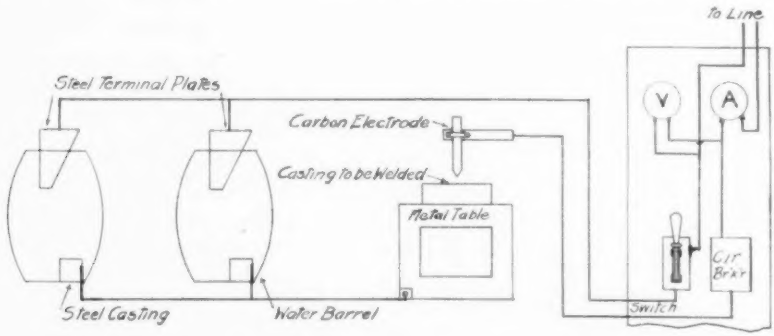

FIG. 29 DIAGRAMMATIC SKETCH OF ELECTRIC APPARATUS. BENARDOS PROCESS

compound, of at least 15 kw. capacity, preferably larger, at 75 to 100 volts, and either belt or direct driven; (*b*) from public supply mains of like voltage and capacity; (*c*) from a battery operating in conjunction with either (*a*) or (*b*). As intimated, current may also be obtained from a higher voltage than that specified, if it is the only kind at hand, resistance being then introduced into the circuit to cut down the voltage to the required amount. This, of course, is wasteful and is recommended only where the welding to be done is so small in amount or of such infrequent occurrence as not to warrant a proper installation. Fig. 30 shows a 200-kw. motor generator, with the motor and generator connected by means of a flexible coupling, but except for the room required a belt-driven outfit could be used equally well.

CONTROLLER APPARATUS

103 Different current strengths are required for different sizes of welds, and means must accordingly be available for regulating the current supply. This is usually effected by inserting a variable resistance in the main current, though in the case of a suitable gen-

erator its field may be weakened instead and the same result accomplished. In the diagrammatic sketch, Fig. 29, the resistance consists of two water barrels arranged in parallel. Pulleys and counterweights are provided by means of which the distance between the terminal plate at the top of each barrel and the steel casting at the bottom may be altered at will and the resistance increased or diminished proportionately. The objection to water barrels is that when the plant is worked hard the water will boil over, thus requiring a stoppage of the work in order to allow the water to cool. The

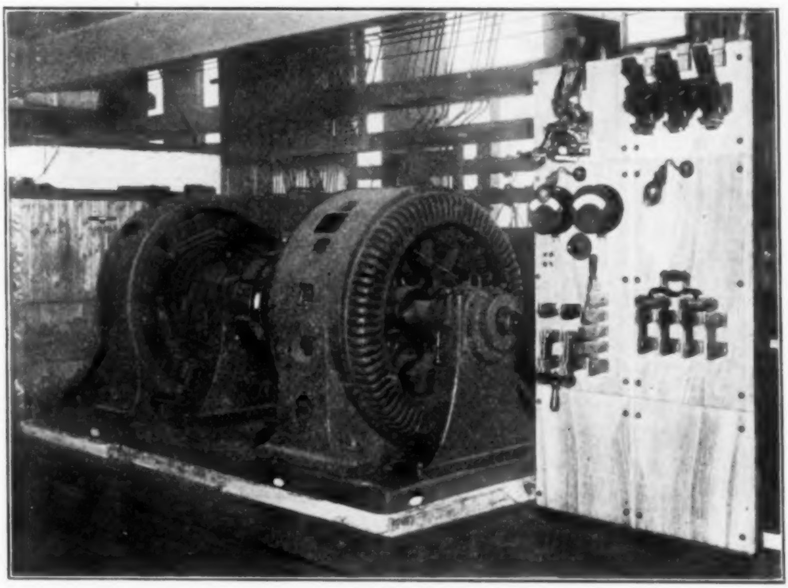

FIG. 30 200-KW. MOTOR GENERATOR OUTFIT

overflowing of the water further causes the hoops on the barrels to rust, which in turn makes necessary the replacing of the barrels from time to time. Again, a spark may occasionally drop into one of the barrels, producing a loud explosion, without damage, however, other than startling the operator. This explosion is due apparently to an accumulation of a small amount of oxygen and hydrogen from the electrical decomposition of the water. For these several reasons it is preferable to use grids instead. Fig. 31 shows the water-barrel device referred to.

ELECTRODES

104 The type of electrode used is illustrated in Fig. 32. It con-

sists of a piece of pipe threaded as shown, and provided with a wooden handle having an asbestos or fiber guard. Into one end of this handle is inserted and clamped the carbon, which in turn is held by pressure in a suitable metal eyepiece. The carbons as a rule are from $\frac{3}{4}$ in. to 1 in. in diameter and 6 in. in length. They should be hard and solid (uncored), of graphite, not of coke, and in burning away should leave a rounded end instead of a pencil point.

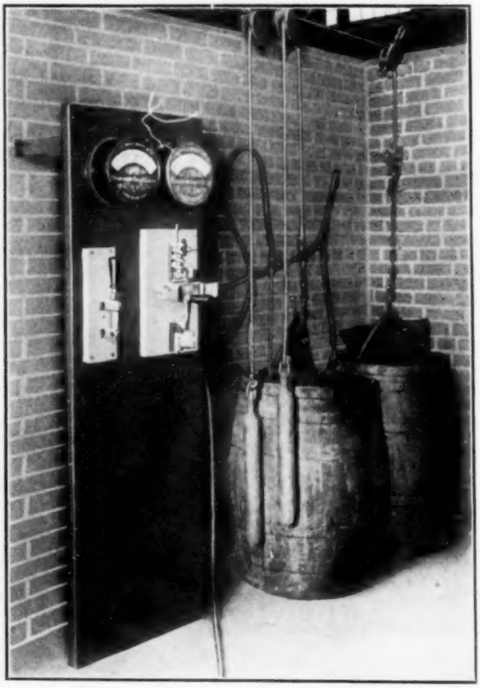

Fig. 31 Water-Barrel Device

ENCLOSURE FOR WORK AND PROTECTIVE COVERING FOR OPERATOR

105 Owing to the intense brightness of the arc the welding must be done in an enclosure, otherwise it would seriously interfere with any other work in the vicinity. It is further necessary to protect the operator thoroughly, as the rays of the arc cause an irritation of the skin much like sunburn, even where the exposure has been of but a few minutes' duration. No more serious consequences ensue, however, and at the expiration of a couple of days all traces of the burn disappear. The clothing is sufficient protection for the body; for the

hands and wrists, gauntlet gloves of pigskin, or even of heavy cotton duck will suffice, while for the head a hood made of canvas, wood or stovepipe, and fitted with a small projecting window of colored glass, is usually worn, Fig. 33. Sometimes the operator prefers to use a wooden shield fitted with colored glass, which is held in one hand. There is some slight objection to the canvas hood, owing to the lack of ventilation; the stovepipe overcomes this objection, but there is the possibility of receiving an occasional shock in wearing it, due to the carbon electrode being brought accidently into contact with it. The wooden helmet has neither of these objections, though it is rather an awkward piece of wearing apparel. Any type of headgear has an appreciable advantage over the hand shield, in that both hands are left free. The window should consist of several thicknesses of glass, red and blue, or red and green, the combination being rather

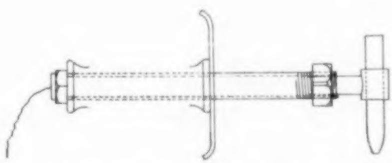

Fig. 32 Type of Electrode Used in Benardos Process

more satisfactory than a single color. The window of the headgear must be made to project an inch or so, for the glass eventually becomes rather hot, and if too close to the eyes will tend to inflame them. In the operation of welding some fumes are given off, but as these are not sufficient to cause any difficulty no special provision need be made to take care of them.

FILLER AND FLUX

106 When welding steel and wrought iron the filler may be soft Norway or Swedish iron, trimmings from boiler-plate, bits of broken steel castings, or the like; for cast and malleable iron, besides any of the preceding, it is permissible to use copper wire or rods of special cast iron which is high in silicon.

107 While flux is not necessary, as a rule, in the welding of steel or wrought iron, it is, however, frequently used in connection with cast and malleable iron, and numerous patents have been taken out along this line. A flux considered very good by many practical welders consists of red oxide of iron (Fe_2O_3), 15 to 25 per cent; borax pulverized ($Na_2Bo_4O_7+5H_2O$), 85 to 75 per cent. Another flux con-

sists of oxide of copper (CuO), 5 per cent; oxide of manganese (MnO_2), 15 per cent; red oxide of iron (Fe_2O_3), 30 per cent; borax pulverized ($Na_2Bo_4O_7+5H_2O$), 50 per cent.

108 These fluxes may be used either dry or wet. If wet they are shaken directly into the weld a little at a time as it is undergoing formation; if dry, a paste is made and the filler rod coated with it and allowed to dry before using.

MAKING THE WELD

109 In making the weld the piece to be welded may be laid

FIG. 33 PROTECTIVE COVERING FOR OPERATOR USED IN ARC WELDING

upon the metal table, shown diagrammatically in Fig. 29, being thus indirectly connected to one terminal of the conduit, or the terminal may, if preferred, be connected directly to it, as in Fig. 33, where no table is used. The resistance in the circuit must next be adjusted for the proper flow of current. The circuit breaker and finally the single-pole switch are then closed, after which the operator takes the carbon electrode in one hand, and has the filler and flux within convenient reach of the other. The hood or helmet, if a hand shield is not used, is then pulled down over the face, and the arc struck by bringing the electrode into contact with the metal and instantly withdrawing it at least three-quarters of an inch. Many operators prefer a still longer arc, as the heating

effect is more regular and better distributed; there is, moreover, less chance of particles of carbon entering the weld and making it hard.

110 If the arc is too fierce or if it goes out too frequently the resistance should be increased or decreased accordingly. Assuming, however, a satisfactory condition, the electrode is given a slow rotating motion, thus causing the arc to heat a larger area than otherwise and to assist in a better distribution of the molten metal. A little of the filling material is added from time to time, the arc meanwhile

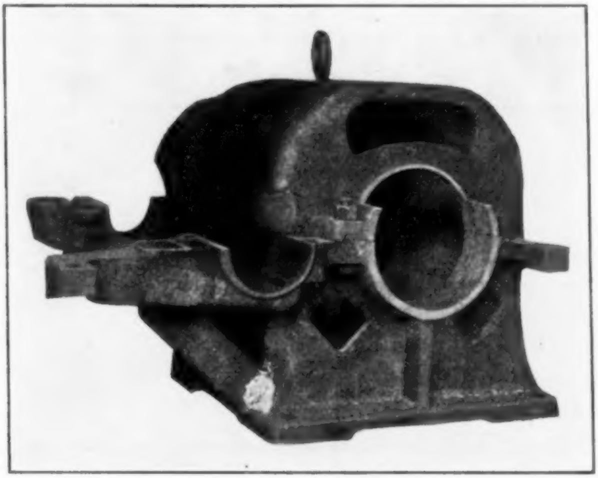

Fig. 34 Steel Casting Received from the Foundry

being continued, if possible, without interruption. When the weld is made, and while still hot, it should be thoroughly hammered to eliminate sponginess from the metal, as well as to give it a finer grain. All impurities must be kept from the weld, and the metal should further be perfectly clean before proceeding with the work. This last is accomplished either by chiseling or by tilting the piece to such an angle that when the arc is applied the molten slag will run off by gravity. The piece may then be righted and the welding commenced.

111 Fig. 34 shows a steel casting received from the foundry minus the piece supporting the rear axle bracket. This defect was readily remedied on a lot of 10 such castings by welding on a wrought-iron bar of the proper dimensions. Fig. 35 shows a steel axle cap before and after welding on one new lug and refilling the other.

112 Occasionally it may be necessary, as in the case of certain iron

castings, to preheat the piece if cracks are to be avoided. This may be done by means of a gas torch turned directly upon the casting; or a small furnace may be built around the piece by means of fire bricks and a gas jet introduced. In the latter case, when the piece reaches a dull red color, the gas is shut off, several bricks in the vicinity of the proposed weld are removed and the weld made. The bricks are then replaced and the casting allowed to cool off gradually and uniformly.

OTHER USES OF THE BENARDOS PROCESS

113 Besides welding, the Benardos process may be used quite advantageously in other ways, as in the removal of sink-heads from

FIG. 35 STEEL AXLE CAP BEFORE AND AFTER WELDING ON ONE NEW LUG AND REFILLING THE OTHER

steel castings, the opening of tap holes and tuyeres in furnaces, the boring of holes in iron plates, the cutting up of steel and wrought-iron scrap, etc.

114 From the nature of the work it will be evident that the compilation of reliable data as to current consumption, strengths of welds, costs, etc., is an exceedingly difficult matter. Nevertheless, certain items may be given for those who are interested in the subject, more however as a guide rather than as representing any especially remarkable performances.

115 Perhaps the most complete published statistics regarding the strengths of welds are contained in a pamphlet published by Messrs. Lloyd and Lloyd of Birmingham, England, the tests (Table 5) being undertaken for them by Mr. Henry Lea of Birmingham, working in conjunction with Messrs. David Kirkaldy and Son of London. These results are excellent, but would seem to be considerably higher than

TABLE 5 MEAN RESULTS OF TESTS OF FIRE-WELDED BARS COMPARED WITH ELECTRIC-WELDED

Brand [1]		Size, In.	Ultimate Tensile Strength per Sq. In. in, Tons of 2240 Lb.	Contraction of Area at Fracture, Per Cent	Extension in 10 In., Per Cent	Ratio of Weld to Solid, Per Cent
Low Moor Iron	F	2 x $\frac{3}{16}$	20.3	15.2	7.3	77.9
	E		21.1	17.3	7.3	81.1
Low Moor Iron	F	2 x $\frac{3}{16}$	21.5	22.3	11.3	90.7
	E		21.8	20.7	9.7	91.8
Netherton Best Iron	F	2 x $\frac{3}{4}$	18.4	10.1	3.4	84.4
	E		20.1	10.8	4.5	92.0
Parkgate Steel	F	2 x $\frac{1}{2}$	20.9	9.3	1.9	69.1
	E		22.3	18.4	3.8	73.6
Parkgate Steel	F	2 x $\frac{1}{2}$	20.4	15.9	8.1	82.3
	E		21.0	15.4	7.3	86.4

[1] F = Fire-Welded. E = Electric Welded.

TABLE 6 LABOR COSTS OF BLACKSMITH VERSUS ARC-WELDED RINGS

Rings		Smith-Welded	Arc (Carbon)-Welded
Section	Inside Diameter		
$1\frac{1}{4}$ x $1\frac{1}{2}$	2 ft., $11\frac{7}{8}$ in.	$0.66	$0.30
$1\frac{1}{2}$ x 2	4 ft., $\frac{1}{4}$ in.	1.13	0.45
$1\frac{3}{4}$ x $2\frac{1}{2}$	5 ft., $\frac{3}{4}$ in.	1.25	0.45
2 x 6	4 ft., $4\frac{3}{16}$ in.	3.05	0.85

TABLE 7 BENARDOS PROCESS. FILLING CAVITY

Line Volts	Arc Volts	Amperes	Diameter of Carbon, In.	Length of Arc
77	43	160	1	$\frac{3}{4}$ to 1
77	42	160	1	$\frac{3}{4}$ to 1
77	45	156	1	$\frac{3}{4}$ to 1

TABLE 8 BENARDOS PROCESS. CUTTING OFF CAST-STEEL SINK HEAD ($2\frac{3}{8}$ IN. x $5\frac{1}{2}$ IN.)

Line Volts	Arc Volts	Amperes	Diameter of Carbon, In.	Length of Arc, In.	Time Required, Min.
75	47	640	$1\frac{1}{4}$	$1\frac{1}{2}$ to 2	4 1-5
75	53	560	$1\frac{1}{4}$	$1\frac{1}{2}$ to 2	4 1-5
75	46	760	$1\frac{1}{4}$	$1\frac{1}{2}$ to 2	4 1-5
75	52	680	$1\frac{1}{4}$	$1\frac{1}{2}$ to 2	4 1-5
75	50	650	$1\frac{1}{4}$	$1\frac{1}{2}$ to 2	4 1-5
75	51	720	$1\frac{1}{4}$	$1\frac{1}{2}$ to 2	4 1-5

should be counted on in ordinary practice. It must be borne in mind, however, that very frequently the material may be thickened or built up in excess of the original dimensions at the weld, thus increasing the strength to a point not otherwise obtainable.

116 A comparison of the labor costs of blacksmith and arc-welded rings is given in Table 6, while in Tables 7 and 8 the current consumption, etc., for various kinds of work are shown.

117 The greatest criticism which may be made of the use of the Benardos process is that apparently, in spite of the best care, the

TABLE 9 SALVIANOFF PROCESS. LAP WELDING $\frac{3}{16}$ IN. STEEL PLATES ON EDGES

Line Volts	Arc Volts	Amperes	Diameter of Electrode, In. Iron	Length of Arc
50	20	160	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
50	24	140	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
50	24	140	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
50	23	150	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
51	20	160	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
51	24	140	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
58	32	180	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
58	22	162	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$

TABLE 10 DATA ON STRENGTH OF WELDS

	Breadth, In.	Width, In.	Area, In.	Ultimate Tensile Strength in Tons of 2240 Lb.		Extension in 4 In., Per Cent	Cold Bend, Deg.
				Total	Per Sq. In.		
Unannealed	1.0	0.56	0.56	15.3	27.4	12	58
Annealed	1.0	0.55	0.55	14.5	26.3	14	160

results obtained are not always uniform, the welds being occasionally hard. Where, however, no machining enters in, this is not a serious matter; in fact, hardness may prove at times an especially valuable feature, as in the repair of bending rolls. If directions have been carefully followed and hard welds are still obtained, the only solution is either to anneal or to remake them.

SLAVIANOFF PROCESS

118 In an endeavor to surmount the difficulty of hard welds, Slavianoff modified the Benardos process by substituting a metal electrode for the carbon, the electrode being usually of the same material as the piece undergoing welding. While in general the process is the same as the Benardos, there are certain details which

require close attention. In the welding of iron or steel the electrode should be of the best soft iron wire, $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in diameter by about 12 in. in length, and the current approximately 125 to 175 amperes at 25 to 30 volts across the arc; the arc itself will not as a rule be over $\frac{1}{8}$ or $\frac{3}{16}$ in. in length, instead of 1 in. or so, as in the Benardos process. Of course, these items will vary within certain limits from the figures

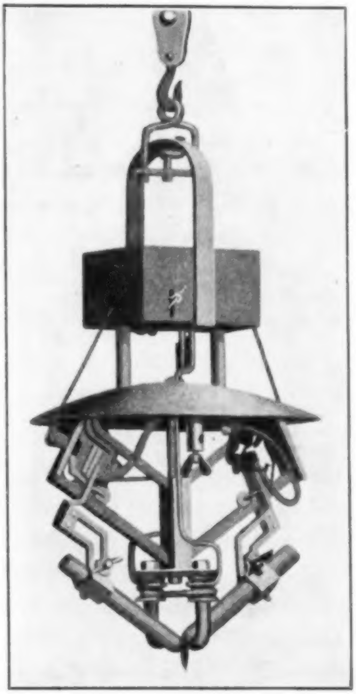

Fig. 36 Form of Apparatus for Zerener Process

given, depending upon the size of the work, which must be carefully studied. A considerable amount of skill is required in the manipulation of the electrode, because of a tendency to stick to the metal when contact is made as the arc is struck. The temperature of the electrode and of the piece in the vicinity of the weld should, if possible, be the same; in other words, both should be melted in order to make a true weld. It is perhaps more frequently the custom to make the metal electrode the positive terminal, while in the Benardos process the reverse is usually true. Certain data as to current, etc., are given in Table 9.

119 The Slavianoff process is used for all welding where strength

is of prime importance, and is in such cases much to be preferred to the Benardos process. It will, of course, be evident from the details given that the volume of work will be considerably less in the same period of time.

120 Regarding the strengths of welds made by this process, Mr. H. Ruck-Keene, in a paper read before the Institution of Marine Engineers, England, gives the data shown in Table 10.

ZERENER PROCESS

121 The Zerener process is apparently not used in this country, and but to a limited extent abroad. Fig. 36, taken from Glaser's Annalen, 1907, illustrates one form of the apparatus which resembles in some respects certain types of arc lamps. The arc is drawn between two inclined carbons and is directed downwards into a pencil point by means of an electro-magnet, the piece to be welded being brought under the influence of the flame and thus raised to the required temperature. The construction of the apparatus and the difficulty of obtaining close regulation of the arc would seem to preclude the use of this process to any large extent.

CONCLUSION

122 Arc welding by the Benardos process covers a field entirely its own which cannot be infringed upon with advantage by any other process. It is unequaled both in cost and speed for large work of the rougher kind and where appearance or finish and strength are not of paramount importance. Where the last item is an essential, the Slavianoff process is to be preferred.

123 Compared with welding either by oxy-acetylene or by oxy-hydrogen, it is the opinion of the writer that both of these gas processes have the advantage over the electric arc processes in the matter of average strengths of welds, as well as in smoothness of finish; but as regards cost and speed the advantage, as stated above, would seem to be the other way.

DISCUSSION ON WELDING

Following the presentation of the preceding papers, there was a general discussion by a number of engineers in attendance at the meeting, from the minutes of which the following brief abstracts and notes are taken[1]:

The electrical resistance process was referred to by W. H. Brown, who explained the action of the common spot welder and of a new type in which the magnetic field is eliminated and the copper losses are reduced to nothing. W. H. Spire[2], continuing on the same subject, stated that his company was making butt welds mainly, and had made welds in almost all kinds of materials. The process had been developed to a point where welds were made in material $\frac{5}{8}$ in. thick, about 2000 welds a day for one man. High-speed steel and machine steel were welded and the results were satisfactory if the material was properly heat-treated afterwards.

W. J. Fritz[3] gave an interesting account of the work done by his company upon the wreckage of the battleship Maine by the aid of the oxy-acetylene blowpipe. The work could have been done only by this or some similar process, or by the use of dynamite, to which there was serious objection—the authorities did not like to blow to pieces the remains of the poor fellows who were entrapped in the wreck.

The thinner metal, up to $\frac{1}{2}$ in. thick, in many cases was so badly corroded that it often required only a few blows from a mechanic's hammer to break it entirely in two. The heavier beams, the boat davits and boat cradles, etc., and protected deck, had to be cut away by oxy-acetylene.

The largest job undertaken while the demonstrator was there was the cutting of the conning tower tube, which consisted of hollow steel, 2 ft. external diameter and 5 in. thick. The operator worked under unusual difficulties, since it was impossible to get into a position where he could watch the cutting action and see what was going on. The tube was cut off in about 50 minutes.

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[1] Complete discussion may be consulted in the Library of the Society.

[2] Electric Welding Products Company, Cleveland, Ohio.

[3] Linde Air Products Company, New York.

A great deal of the steel that had to be cut was backed by the wood of the deck. There was no place for the slag or iron oxide to run through and the wood had become quite decomposed in the water, making it a rather difficult piece of work all the way through. The difficulties encountered can better be understood when the terrific force of the explosion and consequent distortion of the structural members is comprehended. This is shown by the fact that the starboard turret, of steel 12 in. thick, and containing two 10-in. guns, was blown such a distance from the wreck that it has not yet been located.

The question was raised at the meeting as to the strength of welds and the danger of the metal being weakened by burning. J. F. Springer[1] said there were two methods of strengthening the steel, one by increasing the amount of metal in the weld and the other by restoring the steel by an annealing process. The chairman pointed out that there is very little danger of the flame affecting the strength unless it is left alongside the metal. The advantage of a high flame is that it brings the metal to a welding heat in a short time. Also, the envelope of the flame protects the work it blows on, keeping out the oxygen of the air; and with chemical actions going on inside, such oxygen as is present is being taken up and the metal does not burn. It was further suggested that the mere question of temperature at which a workman carried on the operation was not so important, except as a high temperature came in combination with an excess of oxygen or carbon. A point that should be considered is that the welding process produces in the weld a structure which corresponds to cast metal in combination with metal which perhaps is rolled or hammered, or has been through some of the other processes of manufacture. While the character of the metal in the weld can be restored by further working and hammering, anything of that kind is necessarily imperfectly done and introduces uncertainty as to the ultimate strength of the metal.

W. H. Spire stated that in electric welding processes, the resistance method, his company did not guarantee any welds of carbon steel higher than 25-point, unless they were annealed, and it was found of advantage to heat-treat the steel after welding, restoring the metal in the weld and giving it a sort of ironing out.

G. E. Pellissier stated that if it was desired to get nearly the strength of the original metal it would seem necessary to pre-heat it.

[1] 608 W. 140th St., New York.

Even though the metal in the weld were sufficiently strong, the line of demarkation between the cold metal and the molten metal is so sharp there would be a point somewhere at which the strength would not be so great. It had been found of great advantage to preheat so as to divert the heat from the center of the weld back some considerable distance, making the change in the metal from the welded point as gradual as possible, instead of abruptly. It requires much less gas or thermit or any other heat to do the welding if preheating is resorted to.

T. S. Tenney referred to the German practice of welding steam piping for both high-pressure and low-pressure work, and asked to what extent it had been done in this country. Harry Harbison[1] replied that much of the high-pressure work which was formerly made up of short lengths is now made altogether of steel pipe, and where branches come out of the main line, instead of using a casting, a hole is cut and a piece of pipe set in and welded by the autogenous process. He referred to an 18-in. header, 36 ft. long, in one piece, with 10 branches, welded for high-pressure superheated steam work. There had been no complaint about it. Mr. Pellissier spoke of pipe lines welded by the thermit process, reference to certain of which was made in his paper, and one of which, for the New York Central Railroad at Albany, is working under 1500 lb. pressure per sq. in. W. H. Noxon spoke of a large textile concern in Massachusetts that had a complete system of welded steam pipes throughout the plant. They not only use steam for power, but in the processes of manufacture. It was required a short time ago that a welder should go from Boston to the factory and weld in two nipples. The superintendent would not allow them to drill and tap the pipe and screw in the nipples. It is understood that there are no leaks whatever in the piping. When a pipe line is properly welded it does away with a vast amount of repairing afterwards.

Henry Cave, in reference to welding castings, held that little work on large castings had been done under the best conditions. He believed that any part which had been cast and cooled could be welded if the original conditions were reproduced; that is, if the casting were heated up very slowly in a muffle, so that its temperature would rise uniformly to a dull red, it could be welded successfully. He believed, however, that it was practically impossible to weld up a shrinking crack that had occurred during the cooling of a casting,

[1] Simmon's Pipe Bending Works, Newark, N. J.

because the same cause which made it crack in the first place would make it crack in the weld.

CONTRIBUTED DISCUSSION

L. P. Alford had prepared a discussion, which was read in his absence by J. D. Mooney, on the autogenous welding of locomotive repair parts. It related to the use of a largely home made oxy-acetylene plant constructed by The Atchison, Topeka and Santa Fé Railway at Topeka, Kans. Some years ago this company awoke to the enormous possibility of oxy-acetylene welding in making repairs to locomotives. After investigating available equipments, it was decided that all were too small for railroad shop needs. A plant with facilities for supplying 200 cu. ft. of oxygen and acetylene an hour was completed about two years ago and has proven so successful that another plant of the same general design has just been placed in operation. The new plant has a capacity of 1000 cu. ft. of oxygen and an equal amount of acetylene an hour. Oxygen is generated by boiling a saturated solution of bleaching powder in a water-tight tank and adding to this at regular intervals a saturated solution of iron sulphate and copper sulphate. The acetylene is manufactured by the usual carbide feed.

In locomotive repairs the use of autogenous welding is being rapidly extended, and many iron and steel castings and forgings are repaired in this manner at an expense much less than the cost of renewal. Worn parts, such as links, eccentric blades, crossheads, pistons, valve rods, truck and trailer hangers, and waist sheets, are repaired with a considerable saving of time and money. Repairs to steel cabs, steel running boards, ashpans, tender cisterns, and air and oil reservoirs can be expedited and made at reduced cost by the oxy-acetylene process. New work of this nature can be made without joints at reduced initial expense and not unlikely reduced maintenance. With a sufficient supply of gas to permit continuous operation at the necessary pressure, main frames can be welded in position, patches applied to broken cylinder castings, cracked bridges in valve chambers repaired and broken spokes welded in driving wheels.

Nor is the application of autogenous welding confined to the locomotive shop; the advent of steel construction in passenger coaches and freight cars offers unlimited opportunities for it in the car shop. The process is especially suited to the welding of the thin sheets of the head lining or siding and the application of bracing at the window framing in the all-steel coach when being built new; this is also true

of patch work when these parts are in need of repairs. The liability of leaks would be eliminated on oil tank cars if the sheets were welded together in place of riveted, which would be an important item in the transportation of the lighter oils; welded tank cars could be maintained at less expense and would remain in service for longer periods. Repairs to the bodies of steel freight cars can be handled in many instances to better advantage by the oxy-acetylene blowpipe than by the air hammer; this is also true of many repairs to steel underframes.

In the presentation of the discussion numerous slides were shown of repairs that had been made on locomotive parts and cost figures were given. A few of these examples are here referred to, based upon data supplied to the author by H. W. Jacobs, Assistant Superintendent of Motive Power.

By the building up of the crosshead fit on a piston rod and returning at an expense of $3, the old rod is made serviceable. A new piston rod would cost from $12.50 to $18.

Links become worn either by the eccentric blades or by the blocks, making renewal necessary under the old method; however, by building up the worn places with the welding torch at a cost of $4.02, the necessity of supplying a new link at a cost of $43.40 is removed.

The teeth in quadrants become worn and broken, making it necessary by the old method to insert new teeth by dovetailing at an expense of $1.38 for an insertion of two teeth; with the autogenous process two new teeth can be built up and dressed at a cost of 71 cents. The quadrant is considerably stronger when repaired by welding than when repaired by inserting dovetails.

When the back ends of the main frames become badly worn on the top and inside from the working deck casting, it becomes necessary to remove the rame and fittings and to have the frame reinforced at the blacksmith shop, machined, and put back into place. The autogenous process makes it unnecessary to remove the frame. In one case the repairs amounted to $5.25. If the frame had been removed and repaired in the blacksmith shop the total cost of the repairs would have been $41.13.

A crosshead taken from an engine in the shop for general repairs was found to be cracked in front of and above the keyway; it was unfit for further service as it could not be patched satisfactorily. It was welded at a total cost of $3.12 in place of supplying a new crosshead at a cost of $29.40.

The reverse levers become worn by the quadrant reach rod and

latch connections. A lever was built up in the worn places at a total cost of $2.30. To cut out, insert and fit up the central part of the lever would have cost $7.65.

A wrought-iron frame brace became badly worn on one end, due to the action of a spring hanger. To weld on a new end and fit it up, including material cost and labor charges in both blacksmith and machine shops, would have cost $4.42. By building up the worn place by the autogenous method at a cost of $1.69, a saving of $2.73 was effected and the delay to the engine was also reduced considerably.

In making repairs to steel cabs or making changes due to a change of location of the piping, it is often necessary to renew the entire end of the cab in order to secure the necessary strength. In one instance this was avoided by the application of four patches on a steel cab by autogenous welding at a cost of $14.06, as compared with $27.64 for a new end.

Henry Cave[1], in a written communication, took exception to the contention of the author of the first paper that the word "Autogenous" is not a correct term for the use of the oxy-acetylene flame for welding. The weld is made by merely liquifying the parts so that they run together, the liquifaction being produced by applying heat. The application of the heat cannot in itself be considered a part of making the weld, as the weld does not occur until the parts become fluid and run together.

While in a large proportion of the work carried out by this process it is necessary to add metal from a rod, this is merely incidental. The weld as made automatically in a machine, on thin sheet metal, consists in butting the edges together and applying heat, when the parts run together and are actually autogenously welded.

Criticism was also made of the designation made by the author of this paper of the two principal types of torches as "Injector" and "Pressure," commonly referred to as "Low Pressure" and "High Pressure" torches. It was contended in the discussion that all nomenclature should be based on the principal feature of the article being spoken of, and the principal feature in torches relates to the way in which the mixture is produced.

In the "Low-Pressure" or "Injector" type torch the mixture is made by injecting a jet of oxygen through a chamber of acetylene with the result that a stream of gas passes out of the tip having its

[1]President, Autogenous Welding Equipment Company, Springfield, Mass.

core mainly oxygen and an annulus mainly acetylene, the mixture not being homogeneous and the proportion of the two gases varying between 1.00 of acetylene to 1.40 oxygen and 1.00 acetylene to 1.80 oxygen. This being distinctly an injector type torch, the fact that it uses acetylene from a low-pressure generator, or acetylene at a low pressure, has nothing to do with the torch itself, and the use of acetylene under pressure in this torch does not, in any way, affect the type.

In a "Pressure" torch, or what is more correctly termed a "Pressure Positive Mixture" torch, the oxygen flows through a passage in the center under pressure. The acetylene passage is at an angle to the oxygen passage and is also under pressure. The two striking together at a considerable angle and with considerable force, thus giving a very intimate molecular contact of the gases, with the result that a homogeneous stream of gas flows from the tip and the mixture produced contains 1.28 of oxygen to 1.00 of acetylene, the proportion of the gases being positively regulated by the size of the ports through which the gas enters the mixture chamber and not in any way controlled by injector action. The mixture therefore is made in an entirely different manner from the low pressure or injector type torch, and the term "Pressure" is perfectly correct in this case, as is also "Positive Mixture."

This should be emphasized, as those who have not studied the proposition do not realize that an injector type or low-pressure torch cannot be made into a pressure torch by merely increasing the pressure of the acetylene supplied.

One of the obvious uses for this process is the repair and even the manufacture of steam boilers. The regulations governing this class of work, however, restrict its use to some extent. This is entirely due to ignorance of the process and its possibilities, and also to the fact that a great deal of poor work has been produced abroad.

The writer quoted from letters showing that inferior work done abroad, due to the installation of cheap equipments, had been detrimental to the industry and had tended to raise suspicion as to the quality of work which could be accomplished. He advocated the licensing of operators and plants, believing this to be the only way to insure good work being carried out on boilers. By this means there might be a revision of the restrictions imposed. At the present time there are a number of cheap equipments which have been placed on the market in this country, in connection with which it would not be possible to give proper instructions to operators.

It was thought that the author of the paper under discussion might wish to qualify the use of the word "approved" in connection with the apparatus at the Santa Fé shops at Topeka, in which he states that a water to carbide generator is used, in view of the following extract from a paper by the president of the British Acetylene Association:

"I am of the opinion that the dipping or displacement type of generator should not be employed for welding plants; polymerization nearly always occurs in this type and the delivery pressure is an uncertain factor. No one compartment of a generator of this type should decompose more than 4 lb. of carbide per hour, which would yield about 18 cu. ft. of gas. If a generator of this type is allowed to decompose carbide at a faster rate, trouble is bound to come. Overheating will take place in the generator and polymerization will ensue. Some of the hydro-carbons so formed when mixed with acetylene are highly injurious to molten metal, and eradication of some of these hydro-carbons is practically impossible. Not only are they injurious to the metal, but their combustion necessitates more oxygen than is necessary for pure acetylene."

J. F. Springer. The little working flame of an oxy-acetylene blowpipe is very short in spite of the fact that the gases are under pressure. We must conclude, then, that the splitting up of the acetylene into carbon and hydrogen and the subsequent union of equal volumes of carbon and oxygen to form the monoxide must take place in an incredibly short interval of time. Indeed, I do not think it is too much to say that the remarkably high temperature of the white flame is due largely to a lightning-like pairing off of carbon and oxygen molecules.

Theoretically, one volume of oxygen is needed to effect the required results with one volume of acetylene. But with all the oxy-acetylene torches—without exception, I believe—an excess of oxygen is always furnished. In some cases this excess is 50 to 80 per cent. In the Davis-Bournonville torch—and perhaps some others—this percentage is reduced to 28; so that the standard mixture of oxygen and acetylene, which flows from the tips of these torches, consists of 1.28 parts of oxygen to one part acetylene. Now why is it that these various amounts of excess must be furnished? I believe it is due to nothing else than to the varying degrees of perfection with which the *mixing* is accomplished. In the typical Davis-Bournonville torch the oxygen comes into the straight-away mixing chamber along the axis. Just subsequent to its entrance, four acetylene jets strike the oxygen stream perpendicularly from the sides. A proper term for this type of tip would be the ejector tip—the oxygen drives the acetylene. It is not difficult to see that we have here very perfect

conditions. That they are truly so is shown, I think, by the fact that so small an excess of oxygen is required.

The Davis-Bournonville Company is sanguine of putting on the market soon a style of tip whereby the oxygen excess will be cut in two. That is to say, this company expects to use a mixture containing only 13 per cent more oxygen than is theoretically requisite to burn the carbon to the monoxide.

Is this important? Consider a moment. Here is a highly heated steel surface against which the outer end of the little white flame is playing. It is reasonable to assume that hydrogen, carbon monoxide and the excess oxygen are impinging on this surface. The first two are, no doubt, harmless. But how about the uncombined oxygen? Is it harmless? We shall want good reasons to enable us to conclude that a stream of free oxygen playing on red or white hot steel is harmless. It may be urged that with the reduction in temperature, the excess oxygen will be absorbed by the carbon monoxide and the hydrogen. No doubt there is a large amount of such absorption. The generally excellent character of oxy-acetylene welds testifies to this. The ideal thing, however, is to weld the steel without any oxidation. There are three claimants for the oxygen—the carbon monoxide, the hydrogen and the highly heated steel. When the excess oxygen is present in considerable quantity, who can doubt but that the steel secures some oxygen to its own detriment? With the present Davis-Bournonville tip, the excess oxygen is comparatively small; with the new form of tip we have reason to hope it will become well nigh harmless.

HERRINGBONE GEARS

By Percy C. Day

ABSTRACT OF PAPER

This paper relates especially to a type of herringbone gears, known as Wuest gears, after the name of the inventor. The distinctive feature of these gears is that the teeth on one side of the center line of the face are stepped half the pitch ahead of those on the other side, so that they do not meet at a common apex at the center line, as in the ordinary herringbone type. This arrangement makes it possible to hub the teeth by the aid of special machinery, and to secure great precision. The paper further discusses the principles, action, and methods of construction of herringbone gears, contrasting them with spur gears, and gives data upon the proportions and strength of Wuest gears. The paper concludes with examples of the application of these gears to various machines, including cases where high speed, high ratios of reductions and the absence of backlash are to be attained.

HERRINGBONE GEARS

WITH SPECIAL REFERENCE TO THE WÜEST SYSTEM

By Percy C. Day,[1] Milwaukee, Wis.

Non-Member

That the helical principle in toothed gearing is ideal from a theoretical point of view is well known. From a practical standpoint herringbone gears have been less satisfactory than straight-cut spur gears because, until recently, no method was devised for producing them with the requisite speed and accuracy. Within the last six years a method has been found and developed, in England, to a high degree of perfection. Herringbone gears made by this method are called Wuest gears, after the name of the inventor, and can be produced with even greater accuracy than cut gears of the spur type (Figs. 1 and 2).

2 The distinction between these gears and those of the ordinary herringbone type is that the teeth of the former, instead of joining at a common apex at the center of the face, are stepped half the pitch apart and do not meet at all. This arrangement of the teeth does not affect the action of the gears, but it facilitates their commercial production and admits the use of precision methods in their manufacture.

3 The utilization of power constantly calls for means to transmit rotary motion from one axis to another and to transform the speed of rotation. While there are many ways in which such transmissions and transformations may be produced, the merits of all of them must be judged from the following standards: (*a*) reliability and freedom from wear and tear; (*b*) economy of outlay; (*c*) mechanical efficiency; (*d*) compactness; (*e*) evenness of transmission, absence of shock, jar or vibration; (*f*) absence of noise. The order of merit may change with different applications, but the same standards obtain for all

[1] Engineer with The Falk Co.

Presented at the Annual Meeting (December 1911) of The American Society of Mechanical Engineers. All papers are subject to revision.

transmissions. The various methods employed are so well known that they need no discussion here. Let it suffice to say that the spur gear, which satisfies only the first four conditions, is used to such an extent that all other appliances are relatively unimportant.

ACTION OF SPUR GEARING

4 The aim of all designers of gearing is to transmit rotary motion

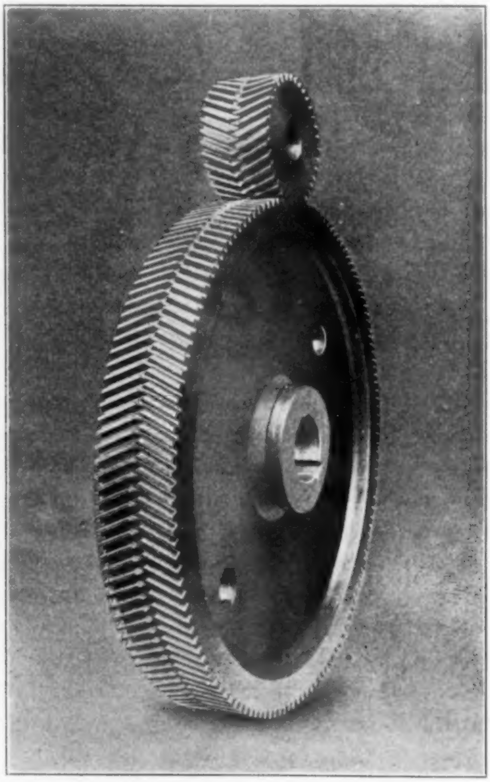


Fig 1 Typical Herringbone Gear and Pinion

from one axis to another in a perfectly even manner without variation of angular velocity. Let us consider the action of a straight spur pinion driving a gear. There are three distinct phases of engagement:

a First phase: The root of the pinion tooth engages the point of the gear tooth.

b Second phase: The teeth are engaged near the pitch line.

c Third phase: The point of the pinion tooth engages the root of the gear tooth.

5 Let us assume that the teeth are accurately cut to involute form, so that if the pinion moves with even angular velocity it will produce corresponding evenness of motion in the gear. Also that the pinion has sufficient teeth to allow the engagement of successive teeth to overlap.

6 At the beginning of the first phase, while the load is carried

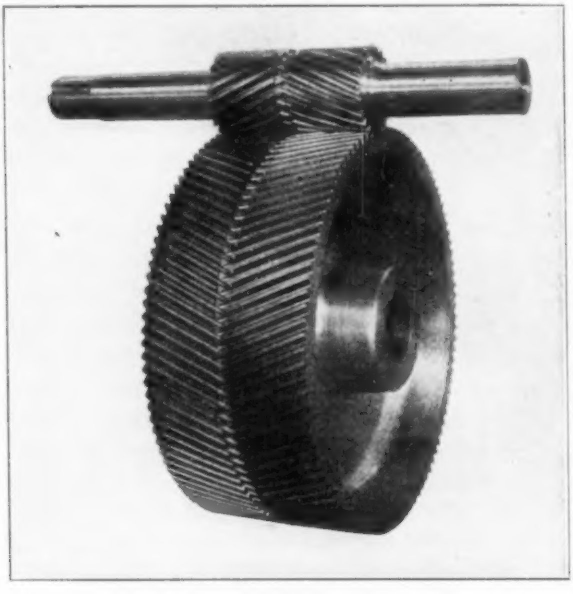


FIG. 2 GEAR AND PINION FOR 200-H.P. TURBINE, TO RUN AT 5000 FT. PER MIN.

near the point of the gear tooth, that tooth is subjected to a maximum bending stress along its whole length. During the first phase, the portion of the pinion tooth near the root is sensibly sliding over the outer portion of the gear tooth; that is to say, two metallic surfaces of small area are sliding under heavy compression.

7 The action during the second phase more nearly approaches ideal conditions. The teeth are engaged near their respective pitch lines and very little sliding takes place.

8 During the third and final phase, the pinion tooth is subjected to a maximum bending stress, while the tooth surfaces again slide

over each other, this time with the outer portion of the pinion tooth engaging the gear tooth near its root.

9 The point to be noted is that while those portions of the mating teeth which are near the pitch lines transmit the load with rolling contact, those which are more remote have to transmit the same load with sliding contact. The inevitable result is that the points and roots of all the teeth tend to wear away more rapidly than the portions near the pitch lines, so that the involute tooth curves, necessary to the preservation of even angular velocity, lose their form and the motion becomes uneven.

10 It may be suggested that the sliding action can be got rid of by shortening the teeth so that they engage only the phase of rolling contact. This has been tried with a certain measure of success in the stub-toothed gear, but it cannot be carried far enough without curtailing the arc of contact so that continuity of engagement is lost, thereby introducing more serious trouble than that which it is desired to avoid.

11 Distortions of gear teeth from involute form, whether due to inaccurate cutting or subsequent wear, give rise to all kinds of trouble. The average angular velocity may be uniform, and yet the passage of each pinion tooth through its brief engagement with the mating gear may be accompanied by successive retardation and acceleration which, though small in itself, takes place in such a short interval of time that it may cause interacting stresses many times greater than the average working load on the teeth. These internal stresses are very difficult to deal with, because they are indeterminate. They cause noise, vibration, crystallization and fracture.

ACTION OF HERRINGBONE GEARS

12 Herringbone gears completely overcome all these difficulties, but only when they are accurately cut.

13 The writer will first assume the accuracy and describe the action, afterwards he will endeavor to show how the system under discussion has special features which insure the production of accurate herringbone gears on a commercial scale.

14 If we take two exactly similar pinions with straight teeth and place them side by side on one shaft, with the teeth of one pinion set opposite the spaces of the other, then we have what is known as a stepped-tooth pinion. If this pinion is meshed with a composite gear made up in a similar manner, the action is modified so that there are always two phases of engagement taking place simultaneously.

Such gears are commonly used for rolling mill work, because they stand up to heavy shocks better than the plain type.

15 Still better action can be secured by assembling a number of narrow pinions with the last of the series one pitch in advance of the first and the others advanced by equal angular increments. As a practical proposition, however, gears made on these lines would be costly and difficult to produce.

16 The helical gear is the logical outcome of the stepped gear carried to its limit, and built up from infinitely thin laminations. Since the steps have merged into a helix, there must be a normal component of the tangential pressure on the teeth, producing end thrust on the shafts. To obviate end thrust, the helical teeth are made right-hand on one side of the face and left-hand on the other. Such gears, with double helical teeth, are known as herringbone gears.

17 The fundamental principle of the action of herringbone teeth lies in the circumstance that *all phases of engagement take place simultaneously.* This holds good for every position of pinion and gear, provided only that the relationship between pitch, face width, and spiral angle is such as will insure a complete overlap of engagement.

18 Since all phases of engagement occur together, it follows that the load is partly carried by tooth surfaces in sliding contact and partly by surfaces in rolling contact. The result is curious and interesting.

19 Those portions of the teeth farthest from the pitch line, which engage with sliding action, tend to wear away more rapidly than the portions nearest the pitch line. But the pitch line portion is always carrying part of the load, and the effect of wear on the ends of the teeth merely tends to throw more load on the center portions; in other words *there is a tendency to concentrate the load near the pitch lines.* The ends of the teeth, instead of wearing away to an ever-increasing extent from their original involute form, are relieved of some of the load from the moment that wear commences to take place. As soon as the load on these ends has been partially relieved and transferred to the middle portion, the wear becomes equalized all over the teeth and they do not tend to distort further from their original shape.

20 It is quite clear that an unmeasurable amount of wear on the tooth ends will be sufficient to relieve them of all the load, so that the distortion from original form will be practically nothing. The minute extra wear that does take place at the ends is only the amount necessary to transfer such proportion of the load near the

pitch lines that the wear is equalized all over the surface of the teeth, those portions in sliding contact carrying less than those in rolling contact.

21 Thus the teeth keep their involute form, and motion is transmitted from pinion to gear in a perfectly even manner, without jar, shock, or vibration. Although herringbone teeth may not be intrinsically stronger than straight teeth, the elimination of all shock and indeterminate internal stresses renders them capable of dealing with far heavier transmitted loads. The concentration of the major portion of the load on the parts of the teeth in rolling contact eliminates friction to a marked extent.

22 Since all phases of engagement occur simultaneously, the transference of the load from one pinion tooth to the next takes place gradually instead of suddenly. This is the second principle of herringbone gearing, and may be termed *continuity of action.* In straight gears the continuity of action is a function of the number of teeth in the pinion. Straight pinions with less than twelve teeth are seldom made, and more than that number must be used if the drive is to be even moderately satisfactory.

23 In herringbone gears continuity depends on the relationship between the face width and the number of teeth in the pinion. Pinions with as few as five teeth have been used with success by merely increasing the face width to suit such extreme conditions. This feature, which is peculiar to herringbone gears, has made practical the adoption of extremely high ratios of reduction hitherto considered impossible.

24 The third principle of herringbone gearing is that *the bending stress on the teeth does not fluctuate from maximum to minimum as* in straight gears, *but remains always near the mean value.* This feature is of special importance in rolling-mill driving and work of a similar nature.

25 To summarize the foregoing arguments: The action of herringbone gears is continuous and smooth; there is no shock of transference from tooth to tooth; the teeth do not wear out of shape; the bending action of the load on the teeth is less than with straight gearing and does not fluctuate to anything like the same extent; the gears work silently and without vibration; the phenomenon commonly termed back-lash is absent; friction and mechanical losses are reduced to a minimum; herringbone gears can be used for higher ratios and greater velocities than any other kind.

26 These advantages are limited to gears which can be produced

with a degree of accuracy which will insure the practical realization of the principles involved.

THE PRODUCTION OF HERRINGBONE GEARS

27 Herringbone gears may be produced in a variety of ways which differ from each other as widely as the character of the product. Until a few years ago all gears of this type were molded. The limitations of molded gearing are analogous to those which would be experienced if a journal were set to run in a molded bearing. Just as the bearing would touch the shaft only in spots, so molded gears utterly fail to give the intimate contact all along the teeth which is necessary to secure the realization of true helical gear action. It is obvious that if the teeth touch only in a few high places, they will be subjected to all the evils of shock, stress, and inequality of motion which it is desired to avoid. If the gears are particularly well molded, some mitigation may be expected when they become well worn, but initial wear is accompanied by a departure from correct tooth shape.

28 For slow speeds a well-molded helical gear is no better than a straight gear with cut teeth, and for high speeds it is not as good. The natural smoothness of helical action does no more than compensate for the inaccuracies of tooth form and spacing. The modern herringbone gear must have cut teeth if its advantages are to become real.

29 Cut herringbone gears may be broadly divided into two classes, two-piece and one-piece gears. The difficulty in the way of cutting double helical teeth in a single blank gave rise to the two-piece variety. The same methods of cutting may be used for both kinds.

30 The disadvantages of the two-piece type are fairly obvious. There is the expense of two complete gears, the difficulty of assembling the gears so they are in accurate register with each other, and the necessity for very complete fixing if they are to perform hard service without getting out of register.

31 High ratios, perhaps the strongest feature of the one-piece type, are not within the scope of the built-up gear, because the pinions must be assembled on a separate shaft and the pitch line must be far enough from the surface of the shaft to allow room for the necessary bolts or rivets used in fastening the two portions together.

32 The one-piece pinion, however, may be cut solid with its shaft, so that its pitch diameter need be but very little larger than the latter.

33 The known methods of cutting helical gears may be divided

into four classes: (*a*) milling by formed disc cutters; (*b*) milling by end mills; (*c*) generating by shaping or planing methods; (*d*) generating by hobs.

34 Milling by formed disc cutters is unsatisfactory because, in addition to the usual errors of step-by-step division, there is the difficulty of making the cutters to the *normal* tooth shape with sufficient accuracy to insure correct circumferential shape for the gears cut. This difficulty is increased by reason of the fact that a disc cutter cannot cut its own shape in a spiral groove. Let it be noted that the cutters must be formed empirically, that their number must be very large to meet the requirements of a general gear business, and that the accuracy of each gear turned out depends on the combined efforts of the toolmaker and draftsman who produced the cutter. Worst of all, two different cutters must be used for a gear and pinion. This method will produce indifferent herringbone gears which may be built up with teeth in register or made in one piece with staggered teeth.

35 The use of end-mills is open to all the objections given with regard to disc cutters, with the single exception that the cutter does leave a fair approximation to its own shape in the groove which it cuts. The end-mill has a host of disadvantages peculiar to itself which render it even less efficient than the disc cutter for general work. In the first place, it is a small tool with very little wearing surface and no capacity for dissipating the heat generated at its cutting edges. The great variation in diameter between point and base renders it difficult to arrive at a cutting speed which will satisfy the conditions at both ends of the cut. When used for any but the largest pitches, outside the range of general gear practice, the mills quickly become clogged with cuttings, overheat and burn. A burnt end-mill, clogged with cuttings, produces a wider groove than a good mill. This is a fruitful source of spoiled work. To complete one fair sized gear by the end-mill process requires quite a number of cutters. This not only makes the expense heavy, but must necessarily result in an inaccurate gear.

36 Every cutter used must be formed to gage and hardened. After being hardened, it will run out of true a little in most cases, thereby cutting a shape different from that for which it was designed. In end-mill gears it is not merely a case of getting accurate conjugate tooth shapes in gear and pinion made with different cutters, but the teeth in a single gear may have a dozen different shapes. The process is so slow that it cannot compete with other methods, quite apart from the doubtful quality of the gears produced.

37 End-milled herringbone gears are usually made in one piece with the teeth joined at the center. Since the cutter is shaped to the *normal* pitch, it follows that, in changing over from right to left-hand helix, it leaves a thick wedge in the center of the face that must be removed by a subsequent operation. The teeth of end-milled herringbone gears do not bear over the center portion.

38 Generating processes by the shaping and planing types, while successful for straight-cut gears of relatively small size, are not used to any extent for large diameters or heavy pitches. The reason for this may be found in the nature of such processes. The gear blank is required to make a quick angular movement after each stroke of the cutting tool and to come to rest again before the next stroke. Such methods are difficult to apply to large gears on account of the inertia of the gear blank and its support and the consequent difficulties of controlling the short intermittent movements. These difficulties are much increased when such methods are applied to cutting helical teeth because the blank must make definite and rapid angular movements during each stroke in addition to the motion between strokes. No machine has been devised which will satisfactorily deal with the problem on these lines.

39 The hobbing process as supplied to straight-cut gears has proved so successful as to arouse a storm of adverse criticism from those who are interested in other methods of gear production. It is not difficult to understand why this process has sprung into prominence in a comparatively short time. It is essentially a rational pro - ess. The shape of the teeth is generated from spiral hobs, the threads of which are cut to a plain rack section. There is nothing empirical about a hob; it is a straightforward thread cutting, gashing and relieving proposition. One hob will cut any gear or pinion of one pitch. This feature alone eliminates a host of errors which are characteristic of gears produced by milling methods. The hob revolves continuously while cutting, as does the gear blank. The feed is also continuous. There are no cutting and return strokes, no intermittent starting and stopping of gear blanks, as in other generating processes. These features do not necessarily insure the production of accurate gears, but they offer greater facilities to the designer for the achievement of the desired result. The hob is a substantial tool with plenty of wearing and cooling surface, it can be made to stand up to very fast production and to last for a long time. The continuous nature of all motions used in hobbing a gear blank enables this process to be used for the production of the heaviest

gears, there are no limitations such as are encountered in other processes. The limit to the size of a hobbing machine is set by the dimensions of the largest gears which are required in sufficient quantities to pay for the investment. There are no technical limits whatever.

40 Nevertheless, there are some slight defects in the hobbing process as applied to the production of straight-cut spur gears. A hob is a worm thread, and as such must have a spiral angle depending on the relationship between the pitch of the thread and the diameter of the hob. A straight-cut gear has no spiral angle, hence the spiral hob must be inclined, more or less, to bring the cutters in line with the tooth spaces to be cut. In order to cut correct teeth, the axis of the hob should be perpendicular to the axis of the gear blank. In such case the hob will generate involute teeth if its threads are cut to the same axial section as the straight-sided parent rack for the required pitch. Since the hob must be inclined to cut a spur gear, the teeth are not generated from the axial or rack section, but from a diagonal section. The axial pitch of a hob for cutting spur gears is not the same as the pitch of the gears, which it cuts. The normal pitch of the hob threads must be the same as the gear pitch.

41 Hobs for cutting straight spur gears are usually made of large diameter to reduce the spiral angle and consequent errors of tooth form to a negligible minimum. As a natural consequence, such hobs have only one thread, while their large diameter requires a slow speed of rotation to keep the cutting speed within proper limits. The effect of this is that the blank revolves very slowly, and a coarse feed must be used to keep up the output.

42 It is one of the peculiarities of each hob action that only one tooth of the hob puts the finishing touch to the bottom of a tooth space once in each revolution of the gear blank. If the feed is coarse, there will be noticeable feed marks and roughness in the gear teeth produced. A coarse feed used with a hob of large radius throws severe stresses on the hob arbor and its supports.

43 The necessity of a swivel motion on the hob slide, to enable straight spurs to be cut with hobs of varying spiral angle, compels the use of a hob drive which passes through the pivot. It is almost impossible to design such an arrangement without undesirable restriction in the dimensions of driving gears and shafts combined with excessive overhang of the hob arbor in relation to its supporting slide.

44 The general want of rigidity about most hobbing machines used for the production of spur gears, is traceable to the above causes.

Rational critics of the hobbing process have based their objections on these features.

45 The hobbing process properly applied to the production of herringbone gears has none of the disadvantages, incidental to its application to spur gear cutting, which have been shown to lie in the necessity of inclining the hob axis. Since a helical gear and a hob must both have a spiral angle, it is only necessary to make the thread angle of the hob the complement to the corresponding angle of the gear teeth to secure the advantages of perpendicular fixed axes. These are of great practical value. Since the hob axis is always perpendicular to the axis of the gear blank, it follows that the teeth are

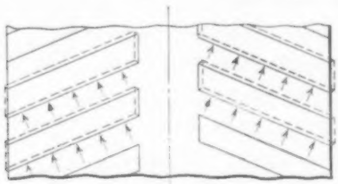


FIG. 3

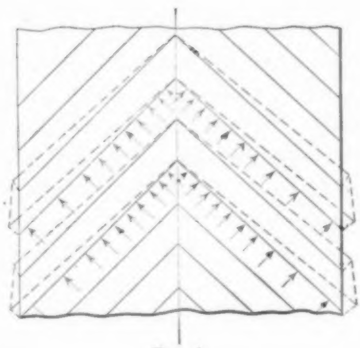


FIG. 4

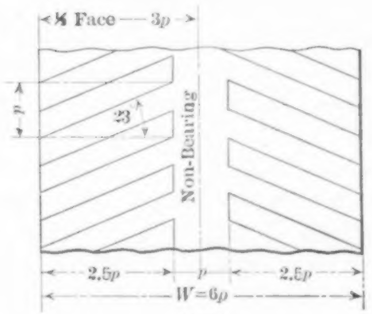


FIG. 5

FIGS. 3 TO 5 DIAGRAMS SHOWING TOOTH PRESSURES AND ANGLE NECESSARY FOR CONTINUITY OF ACTION

generated from the axial and true rack section of the hob, while the linear pitch of the hob is the same as the circular pitch of the gear which it cuts. The hob axis is fixed and the hob can be supported on a rigid slide with the minimum of overhang. There is no restriction to the size and strength of the gears and shafts used to drive the hob.

WUEST HERRINGBONE GEARS

46 It was explained in Par. 2 that the teeth of the Wuest gears are so designed that those on the right and left-hand sides of the

gear are stepped half a space apart and do not meet at a common apex at the center of the face, as in the usual type of herringbone gear. It has often been argued that the ordinary herringbone tooth is stronger than the Wuest tooth, because the latter lacks the support given by the junction of the teeth at the center. This argument would be sound if gear teeth were ever stressed to anywhere near their breaking point. But it has been found in practice that considerations of wear so far outweigh those of mere breaking strength that a gear which is designed to give reasonable service will carry anywhere from ten to twenty times the working load without fracture. A point of vastly greater importance is that the stepped form will wear more evenly under extreme loads than the ordinary type. The reason for this is shown in Figs. 3 and 4. The resultant tooth pressure is always normal to the teeth and tends to bend them apart. The stepped form offers a uniform resistance along its whole length, carrying the load from end to end (Fig. 3). The teeth of ordinary herringbone gears tend to separate more at the sides than near the supported center, causing the load to be concentrated toward the center (Fig. 4).

47 Any system of gearing, if it is to be generally applied, must be interchangeable. The variable features of involute spur gear teeth are limited to the pressure angle, addendum and dedendum. In a herringbone-gear system, we must have, besides, uniformity of spiral angle and relative position of the right and left-hand teeth.

48 The standards which have been adopted for Wuest gears are the result of experience gained in Europe during the last six years. The spiral angle of the teeth is about 23 deg. with the axis. The choice of this angle is controlled by a number of considerations, the most important from the user's standpoint being that the angle must be sufficient to allow the engagement of successive pinion teeth to overlap within a reasonable face width. Once this condition is satisfied, there is no advantage in an increase of spiral angle, while there are disadvantages in the use of steep angles. It was necessary, before choosing a definite spiral angle, to determine what constitutes a reasonable face width for this class of gearing.

49 Since the nature of the action eliminates shock, it follows that the pitch required for given conditions will be much finer than would be chosen for spur gears. On the other hand, the face width will not be less, because there is as much necessity for wearing surface with one kind of tooth as with the other. Spur gears are usually made with face width equal to three or four times the pitch. Herringbone gears may conveniently have a face width equal to six times the pitch

not because the width of this type need actually be greater, but by reason of the pitch being proportionately less.

50 Starting with a width equal to six times the pitch, and allowing once the pitch as the non-bearing portion in the center, there remains two and one-half times the pitch available for the teeth on each side. To insure continuity of engagement under all ordinary conditions, each tooth is inclined so as to cover an advance of once the pitch within its length. The angle of 23 deg. satisfies this requirement (see Fig. 5). There are a few cases where an angle less than 23 deg. would be sufficient, a steeper angle is only needed if the available face width has to be unduly restricted. Neither of these extreme conditions should influence the choice of angle for an interchangeable system best adapted for general use.

51 There are other good reasons why a moderate spiral angle is to be preferred. In all spiral gears the pressure acts in a direction normal to the teeth and is the resultant of the tangential (driving) and axial pressures. The normal pressure becomes greater in proportion to the useful driving pressure as the spiral angle is increased, while the available normal tooth section becomes less (Fig. 6). When the spiral angle is sensibly steeper than the angle of repose for the materials in contact, there is a tendency for the teeth to bind with a wedge action. Herringbone gears with abnormally steep spiral angles show loss of efficiency and increased wear from this cause.

52 The pressure angle which has been adopted for standard gears is 20 deg. The teeth are shorter than the usual standards, with addendum 0.8 and dedendum 1.0. These standards of tooth height and pressure angle have been adopted after systematic trials and experience extending over several years of regular manufacture. The high ratios used with these gears call for an average pinion diameter which is less than is used with straight spur-gears for similar duty. The teeth are generated by hobs, and the short addendum combined with wide angle gives satisfactory tooth shapes, without undercutting of teeth, for small pinions. Pinions with very few teeth are cut on the well-known system of enlarged addendum which is used for small wormwheels and bevel pinions. The teeth are cut to diametral pitch standards, measured circumferentially as with ordinary spur gearing.

53 The dimensions proposed for an interchangeable system for these gears are as follows:

Tooth shape........................Involute
Pressure angle........................20 deg.
Spiral angle........................23 deg.

$$\text{Pitch diameter (20 teeth and over)} = \frac{\text{Number of teeth}}{\text{D.P.}}$$

$$\text{Blank diameter (20 teeth and over)} = \frac{\text{Number of teeth} + 1.6}{\text{D.P.}}$$

$$\text{Pitch diameter (under 20 teeth)} = \frac{0.95 \times \text{Number of teeth} + 1}{\text{D.P.}}$$

$$\text{Blank diameter (under 20 teeth)} = \frac{0.95 \times \text{Number of teeth} + 2.6}{\text{D.P.}}$$

Addendum........................ $\frac{0.8}{\text{D.P.}}$

Dedendum........................ $\frac{1.0}{\text{D.P.}}$

Full depth........................ $\frac{1.8}{\text{D.P.}}$

Working depth........................ $\frac{1.6}{\text{D.P.}}$

Standard face width for gears with pinions of not less than 25 teeth........................6 times circular pitch
Face widths for high ratio gears with small pinions........................6 to 12 times circular pitch

54 When a pinion of less than 20 teeth is used with a standard gear, the center distance must be slightly increased to suit the enlargement of the pinion. If it is desired to keep the center distance to the standard dimensions, the gear diameter may be reduced by the amount of the enlargement given to the pinion. For example: If a pinion of 10 teeth, 5 D.P. is to mesh with a gear of 90 teeth at 10 in. centers,

$$\text{Pitch diameter of pinion} = \frac{0.95 \times 10 + 1}{5} = 2.1 \text{ in.}$$

$$\text{Enlargement over standard pinion} = 0.1 \text{ in.}$$

$$\text{Pitch diameter of standard gear} = \frac{90}{5} = 18.0 \text{ in.}$$

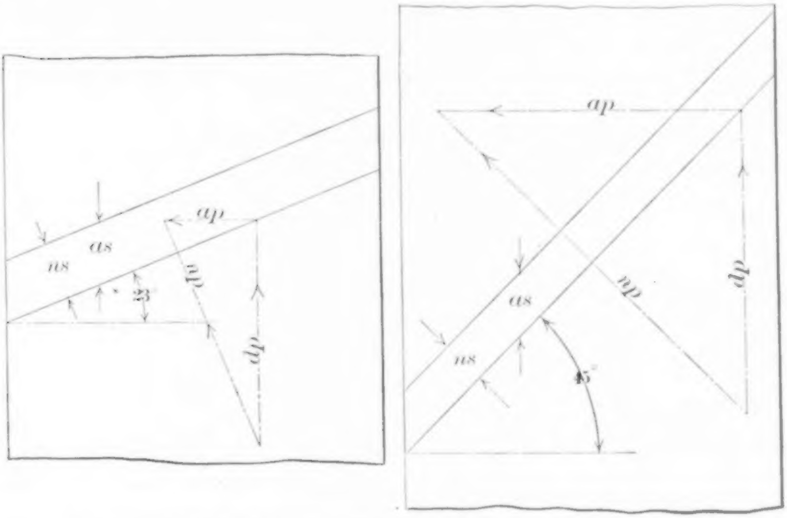
$$\text{Reduced pitch diameter of gear} = 18.0 - 0.1 = 17.9 \text{ in.}$$

$$\text{Center distance} = \frac{17.9 + 2.1}{2} = 10 \text{ in.}$$

Strictly speaking, there can be no enlargement or reduction of the pitch diameter in a pinion or gear of given pitch and number of teeth.

It is convenient to assume this enlargement and reduction, while using teeth with long and short addenda but standard depth.

55 In these gears the teeth need not have the same breaking strength as with spur gears because they have not to combat the heavy and indeterminate stresses which arise from inequalities of angular velocity. On the other hand it is necessary to provide against



		23 Deg.		45 Deg.	
as	Axial Section				
ns	Normal Section	$ns = 0.9205$	*as*	0.707	*as*
dp	Driving Pressure	——		——	
ap	End of Wedge Pressure	$ap = 0.424$	*dp*	1.0	*dp*
np	Normal Pressure	$np = 1.09$	*dp*	1.414	*dp*
	Relative $\frac{np}{ns}$	$= 1.19$		2.0	

Fig. 6

Fig. 6 Relation of Driving Pressure to Angle of Teeth

rapid wear. By using a finer pitch, each tooth has less individual wearing surface, but this is more than compensated for by the larger number of teeth in simultaneous contact than with gears of equal diameters but coarser pitch.

56 In high ratio gears, using pinions of exceptionally small diameter, the pitch is finer than for ordinary ratios, but the face width is extended to give the proper wearing surface.

57 The important factor in determining the proportions of the teeth is the relationship between pitch line velocity and the per-

missible specific tooth pressure; in other words, the total tooth pressure divided by the area of all the available simultaneous contact along the teeth. Theoretically, this contact has no area since it should consist of lines without breadth. Actually, an area exists, due to the elastic compression of the teeth in contact, in a similar way in which an area of contact exists between a car wheel and a rail. The area of contact is indeterminate, but the specific tooth pressure is proportional to the driving stress on the teeth.

58 In order to obtain a simple rule for finding the proper dimensions, the results of experience in the matter of safe working loads

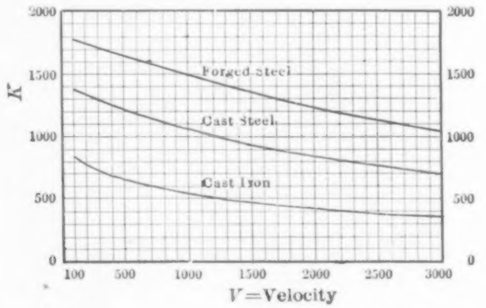


Fig. 7 Shearing Stress in Relation to Pitch-Line Velocity

under given conditions have been reduced to a relationship between pitch line velocity and the shearing stress on the pitch line thickness of an imaginary straight tooth, assuming only one tooth in engagement at a time. The shearing stress is a measure of the specific tooth pressure, and the relationship referred to affords a convenient means of arriving at reliable dimensions. The curves, Fig. 7, give values of shearing stress K in pounds per square inch on pitch line section of an imaginary single tooth for corresponding pitch line velocities V in feet per minute. The values are entirely empirical, but they are based on the results of extended experience, and lead to dimensions which are safe and reliable. Different curves are given for different materials, and it is necessary to use that curve which corresponds to the lowest grade material of the combination. The dimensions of gears can be derived from the curves in the following manner:

h.p. = brake horsepower transmitted
N = revolutions per min.
D = pitch circle diameter, in.
p = circular pitch in inches (use nearest diametral pitch)

W = total width of face, in.
V = pitch line velocity, ft. per min.
P = total tooth pressure at pitch line, lb.
K = stress factor (from curve)

$$V = \frac{\pi DN}{12} \quad \ldots\ldots [1]$$

$$P = \frac{\text{h.p.} \times 33.000}{V} \quad \ldots\ldots [2]$$

$$P = \frac{pWK}{2} \quad \ldots\ldots [3]$$

$$P = 3p^2K \left(\begin{array}{l}\text{in normal gears of moderate ratio, and face}\\ \text{width equivalent to six times the circular pitch}\end{array}\right) \quad [4]$$

$$p = \sqrt{\frac{P}{3K}} \quad \ldots\ldots [5]$$

For high ratio gears take $W = Rp$ (R = ratio to 1) up to maximum of $W = 10p$.

$$p = \sqrt{\frac{2.5\,P}{RK}} \quad \ldots\ldots [6]$$

59 Usually the values of h.p. and N are known. In many cases the diameters or center distances are fixed, and there is no choice of dimensions. When the diameters are not fixed there are many solutions to the same problem and it becomes largely a matter of experience which to select in order to obtain the most economical and satisfactory gears.

60 In normal gears it is safe to aim at pitch line velocities between 1000 and 2000 ft. per min. with 1500 ft. as a fair average. If the pinion is to be fixed to a motor shaft without external support, the diameter must be greater than when it can be supported on both sides. Cast-iron is preferable to cast-steel for gears of large diameters and moderate power, but the latter will be found more economical for high tooth pressures. Pinions are usually made from steel forgings of 0.40 to 0.50 per cent carbon. Soft pinions should never be used for herringbone gears. Besides being bad engineering practice they are unnecessary, because steel pinions run without noise and last much longer.

61 The following is a typical instance of the range of choice in dimensions: A pump which requires 150 h.p. at 50 r.p.m. is to be driven from a motor at 500 r.p.m. with shaft end $4\frac{1}{2}$ in. in diameter.

If the shaft is unsupported, it is not desirable to use a pinion of less than 10 in. If the shaft is extended to a third bearing a $7\frac{1}{2}$-in. pinion can be used. If the pinion is cut solid on its shaft and coupled to the motor, its diameter can be reduced to 5 in. The three arrangements work out as follows:

	Material for Gear	V	P	K	Diametral Pitch	Face Width
A 10 in. and 100 in.	Cast-iron	1300	3800	500	2	$9\frac{1}{2}$
B $7\frac{1}{2}$in. and 75 in.	Cast-iron	975	5100	530	2	12
C $7\frac{1}{2}$in. and 75 in.	Cast-steel	975	5100	1060	$2\frac{1}{2}$	$7\frac{1}{2}$
D 5 in. and 50 in.	Cast-steel	650	7600	1150	$2\frac{1}{2}$	$12\frac{1}{2}$

Any of the above gears will do the work satisfactorily. C is the most economical, but B or D would make the least noise. If a gear case is to be provided then D will give the most economical combination.

62 The foregoing data can be used for finding the required dimensions of herringbone gears for all general applications. In most cases it is sufficient to calculate the tooth pressure from the average working load. When the maximum load is very far in excess of the average, it is usual to take a mean value between the two. Gears for electric mine hoists and single throw pumps fall within this category. Machine tools, when driven from variable-speed motors, are required to perform maximum duty at minimum speed only for short periods at long intervals. It is sufficient when getting out gears for a drive of this kind to reckon with the rated output of the motor at the mean between its maximum and minimum speed.

63 There are two special cases where the ordinary methods of calculation should not be used. Rolling-mill gears are subjected to stresses which are so far in excess of the average working load that it is necessary to consider carefully the strength of the teeth in regard to possible overloads. Extra high velocity gears, as such are used for steam turbines, require additional wearing surface and are characterized by extreme width of face combined with abnormally fine pitch. These are two extremes in gearing and their design is best left to those who have made a special study of them.

64 Before describing some special applications of these gears to the needs of various industries and machines, it may be of service to summarize the salient features of the gears and the changes of viewpoint which these features have engendered.

65 The smooth and continuous action is virtually independent of the diameter or number of teeth in the pinion. Extremely high ratios

of reduction can be used without fear of uneven driving or undue wear and without need for unwieldy gear diameters which would be disproportionate to the general design. High ratio gears of this type transmit power with practically no more loss than low ratio gears. They are far more efficient than belts, ropes, worm-gears or compound trains of spur gearing, while their adoption results in a wholesale reduction of countershafts and bearings which reduces the power consumption and running costs to a remarkable degree.

66 There are many instances where spur gears cannot be used because the vibration which they set up has a detrimental effect on the driven machine or its product. The inconvenience of a cumbersome system of belts or ropes has usually to be borne in such cases, but it is not too much to say that the requirements of almost all of them are fully satisfied by this type of herringbone gears.

67 The application of spur gears has been much restricted by the noise which they make when run at high velocities. The use of rawhide or other soft materials has only proved moderately successful for comparatively light work and is quite unsound for heavy gear practice. Herringbone gears in combination with durable steel pinions make less noise than soft pinions and spur gears when new, and while the former become quieter with use, the latter soon begin to rattle as they become worn. It should be noted that the use of soft pinions, while mitigating the nuisance of excessive noise, does not reduce vibration or unevenness of motion.

68 There is a limit to the pitch-line velocities at which spur gears can be operated beyond which it is unsafe to use them. This limit is far below the minimum velocities which can be used in connection with steam turbines of economical design and high power.

69 Accurate herringbone gears operate quite smoothly at velocities which are impossible for other types. This feature would appear to reserve for them a field of application which has great possibilities and is likely to cause some great changes in the standard practice of today.

APPLICATION TO STEAM TURBINES

70 There are many instances when the power of the turbine can be more conveniently applied in mechanical form than through electrical transmission. The advantages of high-power turbines have been discounted in many instances by the necessity for expensive electrical outfits with their attendant losses of generation, distribution and conversion.

71 Direct-connected steam turbines for marine propulsion have been only partially successful in a very limited field. The screw propeller, working in a dense medium, has an economic speed of rotation which is far below the best speed for a steam turbine of corresponding power. It is only when the power required is very great and the speed of the vessel unusually high that the direct-connected turbine

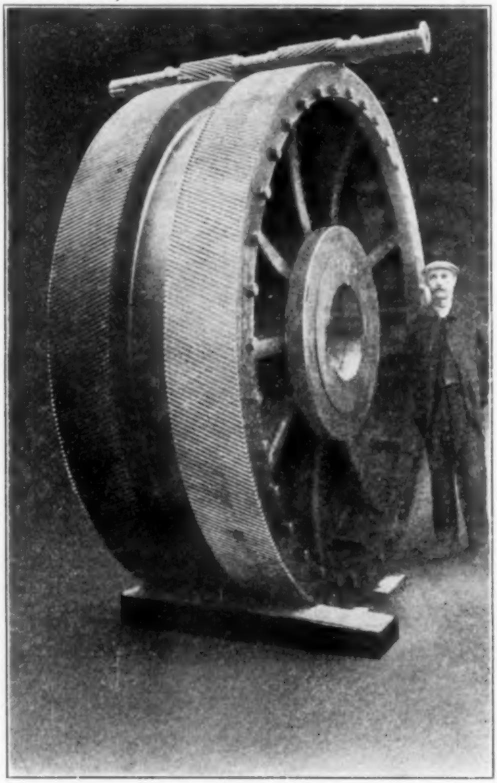


Fig. 8 Gear and Pinion for 500-h.p. Marine Turbine

can be applied, and even then the application does not do full justice to either turbine or propeller, while the first cost is much higher than it need be. The use of direct-coupled turbines is confined to ocean fliers and ships of war. Ordinary vessels of commerce, which are built in vastly greater numbers, cannot be adapted to turbine power in this form. Mr. Parsons attacked the problem of applying the turbine to an ordinary freight steamer of moderate power. To

this end he purchased the S. S. Vespasian, a modern tramp with triple-expansion engines of about 1000 h.p. and a speed of 11 knots with propeller running at 75 r.p.m. As a preliminary to the installation of geared turbines on this vessel, the original engines were overhauled and tuned up and a series of coal consumption trials made under regular sea-going conditions.

72 The engines were then removed and for them were substituted a pair of steam turbines connected to the propeller by the herringbone gears illustrated in Fig. 8. Each turbine develops about 500 h.p. at 1500 r.p.m. The propeller runs at the original speed of 75 r.p.m. Each turbine is coupled to a herringbone pinion with teeth cut solid on a shaft of soft-grade chrome nickel steel. The two pinions mesh with rolled-steel gear rings mounted on a cast-iron spider which is keyed to the propeller shaft. The whole gear system is enclosed in a case, and the teeth are kept lubricated by oil jets. The great width of the pinions in proportion to their diameter made it necessary to provide room for bearings between the right and left-hand teeth. The proportions of this remarkable gear unit are as follows: Pinions, 20 teeth; gear, 398 teeth, 4 diametral pitch; teeth of involute form, 20 deg. pressure angle, 23 deg. spiral angle; over-all face width, 34 in. including 10 in. space for bearing; actual face width, 24 in.; ratio of reduction, 19.9 to 1.

73 This gear has now been running regular voyages for more than a year and has covered over 20,000 miles. The results have been interesting and satisfactory. The efficiency of the gear is fully 98 per cent, including the losses in the bearings on the gear case. The geared turbine shows a sustained all-round saving in fuel consumption of more than 25 per cent over the original engines. The gear runs with remarkable smoothness and without noise or vibration. The wear on the teeth is negligible after 20,000 miles, being only 0.002 in. at the pitch lines of the pinions. Even this small wear is nearly all traceable to inadequate arrangements for freeing the oil from grit during the first runs.

74 Not by any means the least important gain is in the behavior of the vessel in rough water. There has been no racing of the propeller under circumstances where this disagreeable feature was painfully evident with the original installation. This is due to the high rate at which the turbine motors store up energy with change of speed, which makes it impossible for a large change to occur during the time when the propeller is partially uncovered. Such a record as this is so conclusive that the use of geared turbines for marine pro-

pulsion must shortly become general. Herringbone-geared turbines aggregating 3600 h.p. have recently been fitted to the U.S.S.S.Neptune by the Westinghouse Machine Company. The performance of this vessel will be awaited with interest.

75 Mr. Parsons has made a successful introduction of herringbone gears in combination with a steam turbine for driving a continous plate mill. This is a proposition which few engineers would have considered seriously, yet it has proved a success from every point of view.

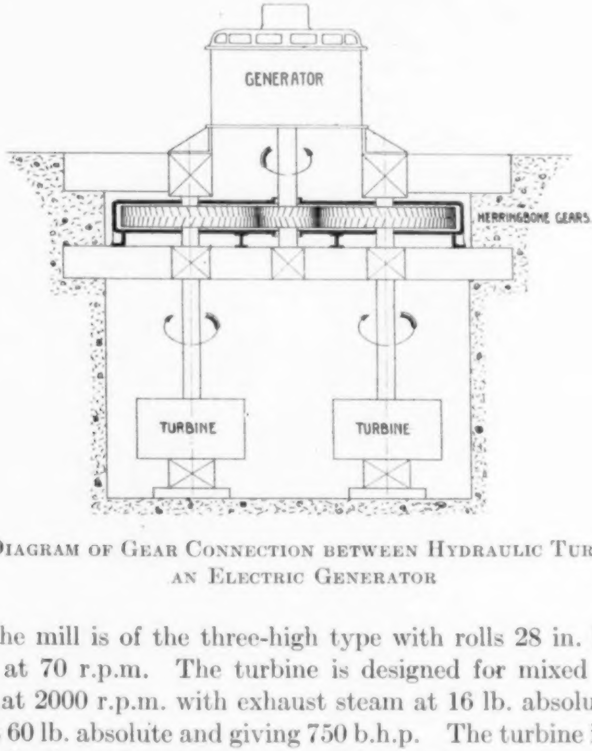


FIG. 9 DIAGRAM OF GEAR CONNECTION BETWEEN HYDRAULIC TURBINES AND AN ELECTRIC GENERATOR

76 The mill is of the three-high type with rolls 28 in. by 84 in. running at 70 r.p.m. The turbine is designed for mixed pressure, running at 2000 r.p.m. with exhaust steam at 16 lb. absolute or live steam at 60 lb. absolute and giving 750 b.h.p. The turbine is coupled to the rolls through a double train of herringbone gears. The first train consists of a chrome nickel steel pinion, cut solid on its shaft and cast-steel gear. Pinion and gear have 25 and 131 teeth, $3\frac{1}{2}$ diametral pitch by 24 in. face. This train reduces from 2000 to 375 r.p.m. and is coupled to the second train through a flexible coupling. The second train includes a high carbon steel pinion of 23 teeth and cast steel gear of 127 teeth, 2 in. circular pitch by 16 in. face. This train reduces from 375 to 70 r.p.m. The final gear is overhung on the

end of a flywheel shaft 22 in. in diameter, which carries a flywheel of about 100 tons between two bearings and is coupled to the main pinion through a pair of wobblers. Both sets of gearing are enclosed in casings and are lubricated by oil jets from a pump provided for the purpose. This mill has been running without a hitch of any kind since September 15, 1910. The gears are noiseless, the installation shows remarkable efficiency, the rolls run with extreme smoothness and the pinions do not show appreciable wear.

77 The success of the geared turbine for such an application as the one described makes it certain that similar arrangements can be used with advantage for driving textile and other mills where the conditions are less severe. The geared turbine is making rapid progress for driving direct-current generators, and several large sets are now running and in course of construction.

78 Hitherto, it has been usual to couple the turbine to a high-speed alternator and to convert to continuous current through a motor generator or rotary converter. The geared turbine unit costs less money, takes up less space and has an overall efficiency at least 6 per cent better than the A.C.—D.C. combination.

79 Geared turbines have another field of application for driving centrifugal pumps. Direct driven units of this kind have poor efficiency because a compromise has to be made between turbine and pump speed which is detrimental to both. The interposition of a set of herringbone gears allows both ends to be constructed for the highest economy, and since the loss in the gears does not exceed 2 or 3 per cent there is a large all-round gain in efficiency. This applies also to turbine-driven blowers and fans.

GEARED HYDRAULIC TURBINES

80 The speed of hydraulic turbines is controlled by the available head of water supplied to them. The greater number of turbines are required to operate under low heads and must run at slow speed. Hydroelectric power has usually to be transmitted to a considerable distance and is produced in the form of alternating current of definite periodicity. The speed of the turbines may be as low as 50 r.p.m. or even less. A large direct-coupled alternator for this speed is an expensive proposition.

81 Herringbone gears can be used to speed up from the slow-running turbines to generators of normal design, speed and efficiency. The smooth action of these gears is unimpaired when the wheel drives the pinion, and high ratios of speed increase can be obtained from them

without noise and with less loss than direct coupled units will give. A typical installation of this kind is outlined in Fig. 9. This arrangement shows two slow-speed vertical turbines driving one generator.

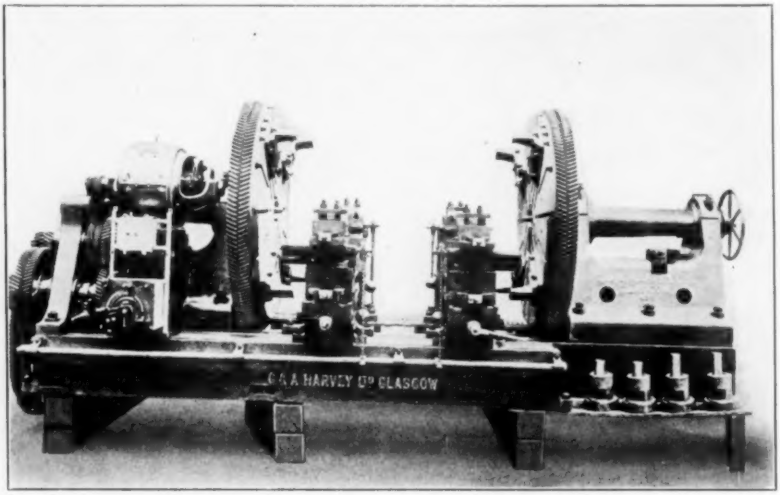


Fig. 10 Tire-Turning Lathe with Herringbone Gears

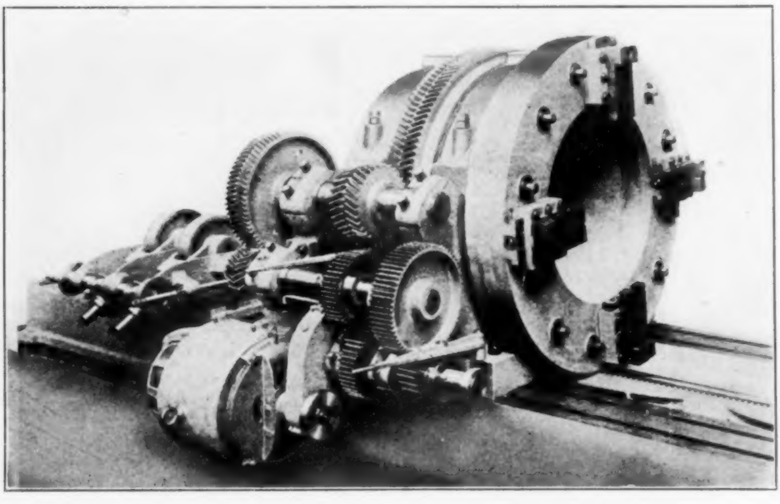


Fig. 11 Gun-Boring Lathe with Herringbone Gears

A herringbone gear is mounted on each turbine shaft and both gears mesh with a pinion which is coupled to the generator.

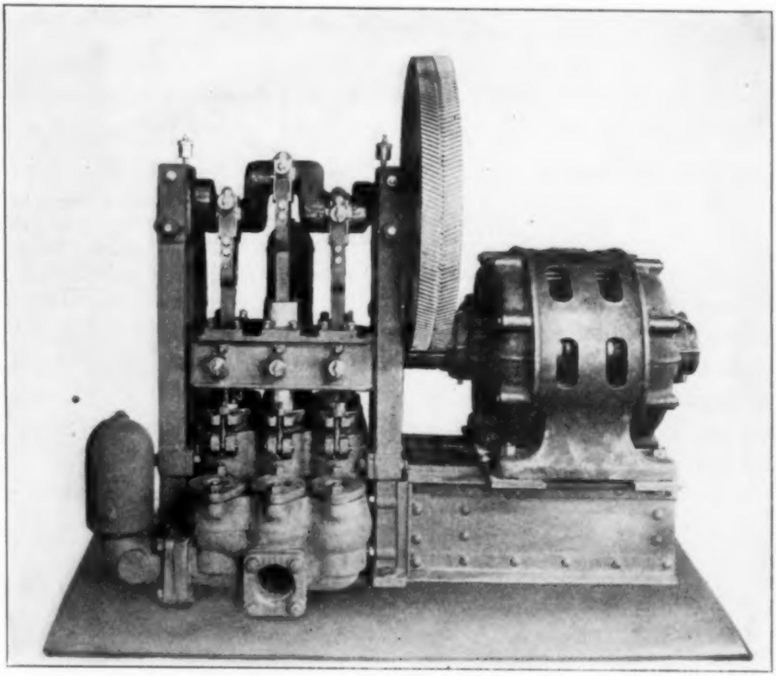


Fig. 12 Herringbone Gears applied to Electrically-Driven Triplex Pump

Fig. 13 Gear-Driven Horizontal Pump, Gear Ratio $12\frac{1}{4}$ to 1

ROLLING MILLS AND ROD MILLS

82 There are two advantages in the use of accurate herringbone gears for this class of work. The absence of shock in transmission renders breakages much less frequent than with cut spur or moulded helical gears. The even transmission and entire elimination of vibration allows the finishing rolls to be gear driven for the finest work without showing gear marks on the finished product. Herringbone-geared mills run with very little noise. This may be of less consequence in rolling mills than in most other applications, but it is an improvement. Rod mills, with their quantities of high-speed gearing, can be completely transformed by using herringbone gears and mill pinions.

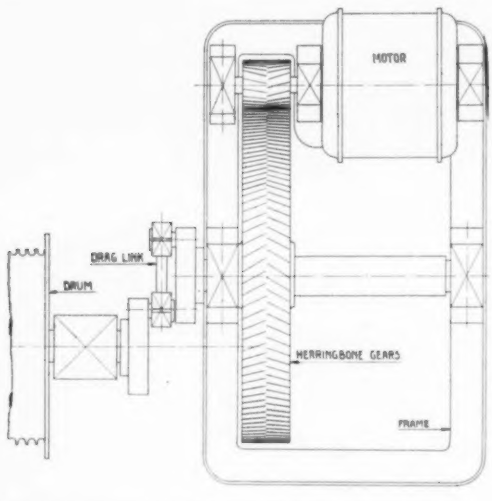


FIG. 14 ELECTRIFICATION OF MINE HOIST FORMERLY STEAM DRIVEN

MACHINE TOOLS

83 The field for accurate herringbone gears in connection with machine tool driving is too extended to be considered in detail. For individual motor drives this gear gives a positive transmission which is free from vibration and less noisy than so-called silent chains or rawhide pinions, while there is no trouble from slipping belts or slack chains. But the real advantage of these gears lies in the better finish that can be obtained when they are used for the entire main transmission, and in the higher output combined with reduced maintenance which they give to heavy machine tools. Chatter is eliminated. Even the speeding up to the wheels of grinding machines has

been successfully accomplished. Reversing gears for heavy planers are a revelation to those familiar only with the ordinary spur drive. Illustrations of machine tool drives are shown in Figs. 10 and 11.

PUMP DRIVING

84 Electrically-driven plunger pumps have not enjoyed the popularity that might be expected, due to the noise and vibration caused

FIG. 15 SEMI-STEEL GEAR, 12-IN. FACE, 12 FT. IN DIAMETER, FOR MINE HOIST

by the gearing between motor and pump shaft. These objections are obviated by accurately cut herringbone gears, which not only give silent and vibrationless transmission but admit the use of high ratio single reductions with compact dimensions. The single reduction drive has a much higher efficiency than the ordinary double train, quite apart from the lower gear losses, because at least one countershaft can be dispensed with. Examples of such drives are

shown in Figs. 12 and 13. Similar drives are successful for air compressors and vacuum pumps which present similar difficulties to those met with in plunger pumps.

APPLICATION TO MINING

85 One of the features in the recent electrifications of the Eckstein group of mines on the South African Rand is a train of herring-

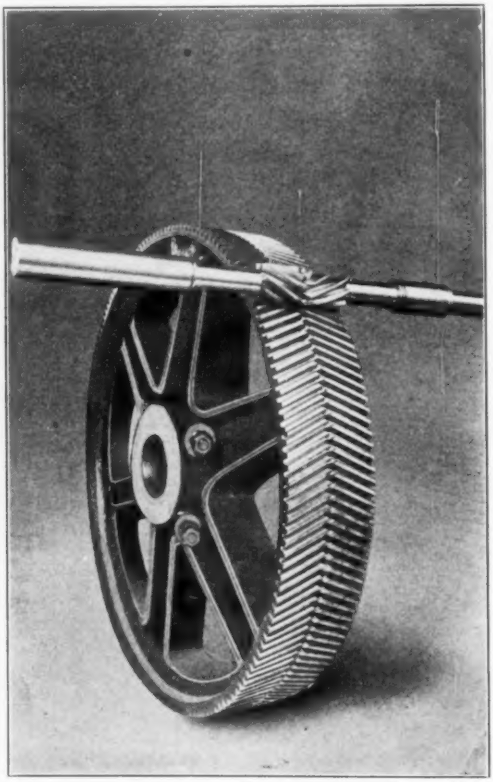


FIG. 16 TYPICAL HIGH RATIO GEAR AND PINION, THE LATTER WITH 8 TEETH

bone gears between motor and drum in the main hoists. These hoists are driven by reversing asynchronous motors; the geared countershafts being connected to the drums by drag links from the original crank pins that were used when the hoists were run by steam power. The arrangement is shown in diagram in Fig. 14. Fig. 15 shows a large gear made for mining work.

86 In installations of this type there are no slipping clutches, and

the strains on the gears are very severe, some of them having to transmit 3000 to 4000 h.p. at pitch line velocities ranging from 2000 to 3500 ft. per min. The large coal mines in Northumberland, Yorkshire and South Wales are rapidly adopting high tension three phase current for the distribution of power below ground. Some very large main and tail, and endless, haulages are used in these and herringbone

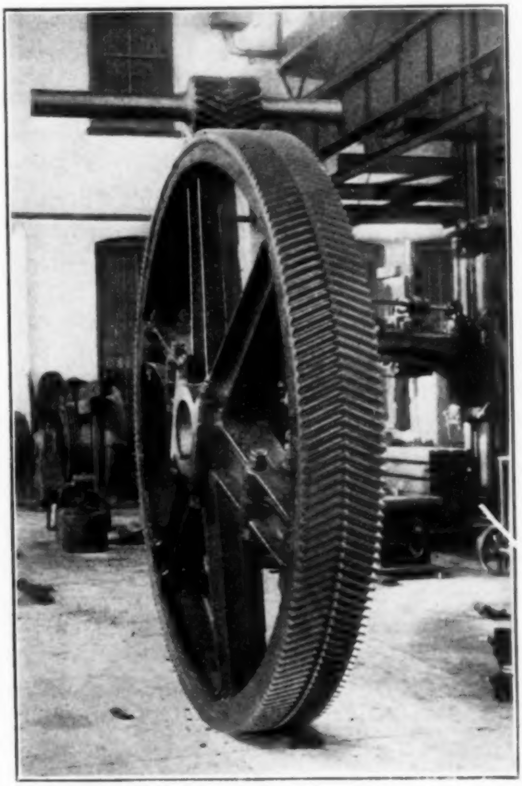


FIG. 17 HIGH RATIO PUMP GEARS, GEAR 9 FT. IN DIAMETER

gears have become a standard for this class of work. The hoists range from 30 h.p. up to 1000 h.p. and invariably use a high reduction with ratios which are sometimes as high as 15 to 1. Simplification of design and saving of space is obtained in this way, since ordinary spurs require a double train. The gain in efficiency and absence of noise are remarkable, while the first cost of the whole outfit is often less than when cheaper gears are used. The elimination of all vibration prevents crystallization of the shafts and disintegration of the insulat-

ing material in the motors. These gears offer the same advantages for endless haulages. A higher speed motor can be used when they are adopted, while no more than two trains of gears are required.

87 An application of especial interest is for driving tipplers. These gears for this purpose have replaced worm gears because they stand up to the heavy strains without excessive wear. The available space for the gears is always limited in such cases. Some typical high ratio gears are shown in Figs. 16 and 17.

ELEVATORS

88 There are very few high buildings in Europe and the elevators there run at comparatively low speeds. As a consequence, worm gears predominate there for this class of work. The Wuest type of gear was brought out with a view to overcoming the losses inseparable from worm gears with high ratios. The needs of American skyscrapers have caused the development of elevators in this country to run on different lines, so that the popular type of today has the rope sheave direct connected to the motor. Needless to say the motor runs at exceedingly slow speed, usually not more than 50 or 60 r.p.m. as a maximum. Such a motor is expensive and inefficient. The system of control is wasteful to a degree. Field regulation is out of the question, and the speed control is obtained by shunting the main current through a resistance so as to reduce the volts across the armature of the motor. The survival of so uneconomical a type of machine is due to there having been no satisfactory gear system which would fit the peculiar conditions. A number of elevators are now being equipped with herringbone gears. The motor is geared to the sheave through a single train with a ratio of about 10 to 1. The maximum motor speed is about 500 r.p.m. and the speed control is nearly all obtained by simple field regulation. The following advantages are claimed: The power consumption is not more than 60 per cent of what is required for direct connected motors, the electrical switchgear is far more simple, has less to do and is not so liable to get out of order; the motor can be repaired without interfering with the car or its suspension.

The Falk Company, Milwaukee, Wis., has acquired the sole rights for the United States under the Wuest patents and during the past year have been constructing some of the most powerful gear-cutting machinery in existence with a view to securing the required degree of accuracy in the production of gears of this type.

GAS POWER SECTION

THE GAS POWER FIELD FOR 1911

By Robert H. Fernald, Mem. Am. Soc. M. E.[1]

Chairman for 1911

The past year of the Gas Power Section has been one of continued prosperity. The progressive policies pursued by the Executive Committee and the various technical committees during the four short years since the birth of the Section have placed it definitely on a basis that assures its future. The reason for its being and the firm belief in a large future for the organization are readily understood by reviewing briefly the steady, healthy development of gas power during the past year—a year that places gas power for large units well beyond the uncertainties of the purely experimental period.

LARGE GAS ENGINE UNITS

The development of large gas engine units has gone steadily forward for the past decade. The first engine of this class was that exhibited by the John Cockerel Company at the Paris Exposition in 1900. This was an engine of 600 h.p. rating. At the present time 1500 h.p. in each cylinder of the 4-stroke cycle type and 2000 h.p. in each cylinder of the two-stroke cycle engine are reported as one of the exhibits at the recent exposition at Brussels. This means units of 8000 h.p. of the twin-tandem double-acting type. The present status of the large blast-furnace gas-power plants has been ably and thoroughly presented at recent meetings of this Section, and the papers and discussions form a valuable portion of the proceedings of the Society.

It is understood that at least one company is prepared to install gas engine plants of large power capacity at a cost not exceeding and in some instances less than that of the corresponding steam turbine installations.

[1] Address of the retiring Chairman read at the Annual Meeting, December 1911.

MARKED STRIDES IN THE DEVELOPMENT AND APPLICATION OF THE DIESEL ENGINE

Although the steam turbine has superseded the reciprocating steam engine for electrical development in central station work, and will probably hold the field for some time to come, it is interesting to note that the Diesel engine, owing to its great success in small station work, is looked upon seriously as a possible rival to the steam turbine within a short time. In a paper recently presented before the Municipal Electrical Association at Brighton, England, the relative cost of a 10,000-kw. installation for steam turbines, gas producers and engines, and Diesel engines, was discussed at length. The author's proposition was to use seven sets each of 1450 kw. capacity. His figures of operating expense, etc., are decidedly in favor of the Diesel engine installation.

Attention was also called to the very economical use of these engines as a substitute for substation converting machinery. Such stations are already putting in their appearance in London.

In this connection it is interesting to note the development in point of size of the Diesel engine. Engines of a few hundred horsepower have become European practice. In Swiss electric stations Diesel engine units of 2000 h.p. are now in use, and one writer on the subject states that the development of the large sized Diesel engine has been so successful that it will not be long before 1000 h.p. developed in one cylinder will be thought nothing extraordinary. One company of world-wide reputation is at present considering more than 2000 h.p. in the single cylinder of Diesel engines. It is stated that engines of this type with four cylinders developing 1000 h.p. each can be made as light as the corresponding triple expansion steam engine.

The weight of such engines compares favorably with that of the corresponding turbines and boilers. It is understood that a 1000-h.p. installation of this type weighed only 187 lb. per h.p. as compared with 180 lb. for a steam turbine and boiler installation.

The crude oil engine is now definitely under consideration for all types of marine craft. For small vessels the advantage lies in the safety afforded by the use of crude oil as compared with lighter oils. The crude oil engine is being used by many of the principal navies of the world for submarine boats, and designs are already under way for comparatively large engines for torpedo boats and similar craft.

A few months since, the Vulcanus, a vessel of 1900 tons displace-

ment, 196 ft. long, equipped with 6-cylinder 4-cycle single-acting reversible Diesel engines, was put in regular service between Holland and Borneo. This engine is about 500 b.h.p. capacity at 180 r.p.m. The fuel is a crude oil from Borneo and the quoted guarantees are 0.42 lb. per b.h.p-hr. at full speed; 0.44 lb. at three-quarters speed; and 0.5 lb. at half speed. In a recent trip the Vulcanus covered 3312 miles in 19 days and 3 hours. The average speeds varied from 6.86 knots to 7.80. It is understood that the average consumption for this ship amounts to 1 ton of fuel oil per 100 knots.

The technical journals of recent date record many such installations. Among these Russia is credited with at least four freight vessels of 1000 h.p. and two 14-knot gunboats of the same horsepower rating.

This month two vessels nearly 400 ft. long of 7000 tons capacity, each fitted with Diesel engines of 2500 h.p. rating, and with two auxiliary Diesel engines aggregating 500 h.p., will be tried out in European waters.

A recent announcement is to the effect that the Hamburg-American Company propose to build an ocean liner using oil engines for motive power.

In this connection attention is especially directed to the most recent development in the oil engine field—the Junkers marine oil engine. These engines for the freight vessels of the Hamburg-American Line, are of the twin-tandem type of 1600 total shaft h.p. each. The engines operate on the 2-cycle principle, and through the introduction of two pistons into each cylinder double action is secured.

An interesting comparison will shortly be placed before the public by the British Admiralty, as it is proposed to try out side by side in a twin screw cruiser a steam engine and a Diesel engine of 6000 h.p. rating.

Another destroyer recently ordered by the British Admiralty, according to current reports, will have on each shaft a steam turbine and a Diesel engine. The plan is to operate the turbines when high speeds are required, but under cruising conditions, when the speeds are low, owing to the poor economy of the steam turbines, the Diesel engines will be used. The combined economy due to this arrangement will be exceedingly interesting.

One of the interesting features of these engines is the fact that there seems to be a marked tendency toward the 2-stroke cycle for marine work.

With the introduction of these engines the discomforts of the stoke hole will be greatly reduced, and the amount of labor required will be less than under present marine conditions, and the character of labor much improved.

Although it is not probable that steam installations are to be rapidly displaced in the larger ocean going craft, yet the crude oil engine seems to be especially adapted for such service as that previously indicated. The fuel needed approximates a third of that required for the steam engine, thus greatly increasing the radius of action if the same weight of fuel be carried. Boilers can be done away with and their space utilized for carrying cargo.

It is reported for a freight vessel of 2700 tons that a saving of over $19 per day was made by using oil at approximately $11 per ton, instead of coal at about $3 per ton.

TAR AS A FUEL FOR DIESEL ENGINES

Tar oil has become more or less common as a fuel in Diesel engines of 600 or 800 h.p. rating, and it is understood that it is used in at least one engine of 4000 h.p. rating. Recent experiments indicate that both thin gas retort tar and thick coke oven tar can be used in a similar manner by injecting into the cylinder a small percentage of light oil to assist in igniting the tar. It is claimed that a wide range of tars can be used in this manner without producing smoke or appreciable residue. In tests at the Koerting works about 2 per cent of the ignition oil was used at full load and about 13 per cent at half load. Reports indicate that an order has been placed for a 600-h.p. Diesel engine to operate on raw tar.

INTERNAL-COMBUSTION ENGINE LOCOMOTIVES

Locomotives using internal-combustion engines and operating on the standard gage track have recently been put into service. The range of fuel for these engines covers gasolene, benzol, alcohol and petroleum.

The Prussian State railways are reported to be operating a 1000-h.p. locomotive using a Diesel engine as motive power.

GAS TURBINE

Results are soon to be expected from the more recent investigations and tests relating to gas turbines. It is believed that some of the types are based on correct principles, and that after a rotary air compressor of satisfactory design has been secured rapid progress in the development of this prime mover may be expected.

RECOGNIZED RELIABILITY OF INTERNAL-COMBUSTION ENGINES

Not only do the renewed and increased orders for internal-conbustion engines by the great manufacturing corporations indicate a feeling of assured reliability, but the subsidizing by European war departments of petrol motor Lorries indicates a feeling of reliability in the internal-combustion principle that is beyond dispute. These vehicles will be held subject to purchase in case of need by the war department. An important stipulation is: "The engines must be of the internal-combustion type using petrol, and by preference having four cylinders."

THE HUMPHREY PUMP

This internal-combustion pump has been before the gas power public for two or three years past. Many similar internal-combustion pumps are clamoring for admission to the field. The comptroller, in discussing the validity of the Humphrey patents, states "The Humphrey pumps show an important advance in the art. Although many applications have been filed for patents since 1858 none has embodied the principles of the Humphrey pump."

The 1000-h.p. pump occupies about the same space as the tandem double-acting gas engine of the same power.

Mr. Humphrey says: "With the compression pressure of 11 atmospheres absolute the theoretical thermal efficiency of the cycle is 52.5 per cent, whereas that of the Otto cycle is only 40 per cent when all corrections for varying specific heats are allowed for. With very moderate compression, under 50 lb., an actual thermal efficiency of 23 per cent has been obtained on a 4-cycle Humphrey pump. This corresponds to 0.95 lb. of anthracite per hydraulic horsepower hour, and was obtained on a lift of only 35 ft."

ILLUMINATING GAS FROM SEWERAGE

A report is current to the effect that the municipality of Bruss, Austria, is to convert the solid residue from the town sewerage into illuminating gas. The figures reported indicate that 1 lb. of solid residue is secured from 60 gal. of sewerage and that 380 cu. ft. of gas are obtained from each 100 lb. of solid residue. The calorific value of the gas is reported as at least equal to and the light better than that of coal gas.

UTILIZATION OF THE WASTE HEAT OF THE GAS ENGINE

Various methods of utilizing the waste heat of the gas-engine exhaust have been attempted from time to time and the demand for

such devices for heating buildings has been considerable. Several schemes for accomplishing this result are now commercially in use, but according to recent opinions the most efficient method of utilizing the exhaust is through a combination of gas and steam engines.

Present practice indicates that about 3 lb. of steam are generated per b.h.p-hr. by means of exhaust boilers.

According to Mr. Chorlton the use of exhaust boilers with efficient steam engines and specially designed gas engines of the 2-cycle type will effect marked thermal economies and reduce initial cost of the installation per horsepower.

One of the technical journals states that Mr. Chorlton shows by numerical examples the possibilities of such an engine, first examining the case of the addition of a steam end to a normal economical gas engine. He assumes a standard engine to use 9500 B.t.u. per b.h.p-hr. As the engine is ordinarily arranged with jacket feed to the boilers we may take 40 per cent of this amount to be recoverable. From this at 80 per cent efficiency of conversion at 100 lb. pressure we would recover about $2\frac{1}{2}$ lb. of steam per b.h.p-hr. This amount in an ordinary simple steam engine would not give more than 10 to 12 per cent of the main engine power, a return which hardly justifies the first cost of the steam cylinder. Consequently no development has taken place in this direction.

When, however, we are dealing with a special combined compound engine, each part of which is made in the most suitable way for the purpose required, we get a very different result. In order to reduce the cost of the gas engine part the compression would be lowered, and with the ignition retarded a much lower maximum pressure and temperature would result; the total heat units used would go up to, say, 12,000 B.t.u., but more would be rejected to the exhaust, and with a special arrangement of boiler, economizer pipes, superheaters in exhaust, etc., 50 per cent waste heat should be recoverable. There should be obtained from this 4 lb. of steam per b.h.p-hr.

The steam cylinder used would be similar in type to that of the 2-cycle engine, that is, with no exhaust valves. The unidirectional flow engine of this type has been largely re-introduced in Germany with very economical results. The jacketing of the ends could be done by exhaust gas. For small engines of this type it is safe to assume a steam consumption of 12 lb. per b.h.p-hr.; a consumption of 10 lb. has been obtained in actual practice. Hence the power obtained from the steam cylinder would be one-third of that or the gas cylinder, and the consumption for total effective power would

be reduced to 9000 B.t.u. per b.h.p-hr., less than that for the economical gas engine alone.

SURFACE COMBUSTION

By what he terms "surface combustion" Professor Bone reports for gas fired boilers evaporations of 21.6 lb. per sq. ft. of heating surface and an efficiency of heat transmission of 94 per cent. The heat balance of a test reported by him shows:

Gas burned per hr. (at 32 deg. fahr. and 14.7 lb.), cu. ft.	997
Net calorific value of gas, B.t.u	562
Total heat supply to boiler per hr., B.t.u	559,800
Temperature of feedwater, deg. fahr.	42
Pressure of steam, lb.	100
Water evaporated per hr., lb.	450.3
Water evaporated from and at 212 deg. fahr., lb.	550
Heat transmitted to water, B.t.u.	450.3 x 1172 = 527,800
Heat ratio 527,800 ÷ 559,800	0.943

In the reports of the surprising results of these investigations attention is called to the fact that the combustion was perfect, as was shown by analysis. An efficiency of 94 per cent was obtained. Deducting 4 per cent for the power required for supplying air pressure still leaves 90 per cent.

Professor Bone says: "The new boilers could be set up in brick work and require no elaborate flues or chimneys. They are liable to no strains as they are short. With some sacrifice of efficiency the evaporation could be raised to 30 lb. per sq. ft. The steam was raised quickly (steam at 100 lb. pressure obtained in 20 minutes from cold start), and tubes could be grouped and cut out separately so as to vary the fuel consumption to suit the fluctuations of load."

In the first foot of the tubes 65 per cent of the steam was generated; 25 per cent in the second foot, and 10 per cent in the third.

PRODUCER GAS FROM LOW GRADE FUELS

Progress is steadily being made in the utilization of lignite, peat, and high ash coals in producer-gas work. The investigations of the Canadian Government show that peat can be prepared for fuel purposes at a cost averaging from 30 to 40 per cent of that of an equivalent B.t.u. value in anthracite in Canada.

As the foundation of a method that may result in extensive use of high ash fuels without prohibitive cost of operation, attention is directed to the present producer-gas investigations of the United

States Bureau of Mines, resulting in the successful fusing of the ash and the use of water-cooled producer linings.

In line with this specific conservation of fuel resources it is interesting to note that one estimate states that the United States Steel Corporation alone, through its installations of blast-furnace gas engines, displaces or saves a consumption of approximately 1,000,000 tons of coal per annum as against the old-fashioned methods.

SMALL PRODUCERS FOR BITUMINOUS COAL

Reports are persistently before us indicating the successful development of gas producers of small power to operate on bituminous coal, coke breeze, anthracite screenings, "front end cinders," etc.

Such plants are in great demand, but it is doubtful whether the development and application have been as great as the advertising these plants receive. It is interesting to record, however, that a company manufacturing anthracite gas producers and gas engines which expressed its firm conviction in 1904 that the Government tests with bituminous coal in producers would fail utterly, recently put itself on record as recommending the use of its own engines with small bituminous producers manufactured by another company.

CRUDE OIL GAS-PRODUCERS

The development of the crude-oil gas producer, for which there is great demand in oil regions remote from the coal field, has been exceedingly slow, but it is believed that very definite progress has recently been made along this line. The most recent notes on this subject relate to the Grine oil producer. In this type steam spray is used for atomizing the oil which is introduced into the upper part of the generator where partial combustion takes place. The down-draft principle is then applied and the hydrocarbon broken up and the tar fixed by passing through a bed of incandescent coke. Mr. Grine reports that a power plant using one of these producers has been in operation a year in California. With crude oil as fuel costing 95 cents per bbl., or 2.3 cents per gal., the plant is reported to develop the same amount of power per gallon of crude oil as is ordinarily developed by the standard internal-combustion engine operating on distillate at 7 cents per gal. Including the cost of fuel, labor, supplies, interest, depreciation and taxes, Mr. Grine states the cost per b.h.p-hr. to be 0.76 cents for a plant of 100 h.p. rating.

The opportunity for investigation in the gas power field is at present unlimited, as is evidenced by the fact that nearly 100 im-

portant gas-power problems are at present on file at the United States Bureau of Mines under the head of Proposed Investigations.

It is gratifying to note that each year removes many of the absurd prophecies regarding the elimination of practically all prime movers save the internal-combustion engine, and that the past year may be regarded as one of steady, conservative progress and development in a field that is of keen interest to so large a percentage of the total membership of The American Society of Mechanical Engineers.

FOREIGN REVIEW

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

An Index to Current Articles in Foreign Periodicals, with Abstracts of Some of the More Important

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TOPICAL INDEX OF CURRENT ARTICLES

ARTICLES WITH STARS ARE ABSTRACTED MORE FULLY IN PAGES WHICH FOLLOW

Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *a* comparative; *b* descriptive; *c* experimental; *d* historical; *e* mathematical; *f* practical; *g* general; *h* theoretical. Articles of exceptional merit are rated *A* by the reviewer.

AERONAUTICS

ÉVALUATION DU TRAVAIL DE L'HÉLICE EN FONCTION DE LA FORCE VIVE, L. Legrand. *Revue universelle des mines et de métallurgie*, August. 30 pp., 7 figs. *Ae.*

Contrary to the generally accepted views, the author claims that the *theoretical expression of the work of an aerial propeller* in motion is not ½ Mv^2, but its double, Mv^2. He finds that this analytical calculation is supported by the experiments of Riaboushinsky, and that the coefficient of efficiency of a propeller revolving at a fixed point (fan) is about half that of an aerial propeller in motion.

RÉSISTANCE DE L'AIR APPLIQUÉE À L'AVIATION, J. Chovet. *La Revue de l'aviation et des sports*, October. 2¾ pp., 4 figs., 4 tables. *c.*

The generally used formulæ, *resistance of air* $F = KSV^2 \sin^2 \alpha$, pressure $P = KSV^2 \sin^2 \alpha$, can be used only under certain conditions. The author replaces them by the following formulæ: for angle of α not less than the angle of curvature of the plane β: $F = k0.067 \sin^2 (\alpha + \beta)$, and $P = \frac{C \sin^2 (\alpha + \beta) \cos\alpha}{\sin \alpha}$, where k is the ratio between the breadth of the wing and its thickness, and α and $\sin^2 (\alpha + \beta)$ are obtained from tables from Mr. Eiffel's experiments. The author calculates also a resistance R normal to the plane, and finds that it is equal to $\frac{C \sin^2 (\alpha + \beta)}{\sin \alpha}$. The article is to be continued. Tables give values of constants and variables used in the formulæ.

AIR MACHINERY

CALCUL DES COMPRESSEURS CENTRIFUGES, Ch. Lemale. *La Technique moderne*, November. 3½ pp., 8 figs., 3 curves. *e.*

Discusses the theoretical bases, and gives mathematical methods for the *calculation* of orifices *for piston and multicellular compressors*, of output, pressure, and of shafts, rigid and flexible, giving a graphical method for the calculation of a rigid shaft with two supports.

TRYCKLUFTLOKOMOTIF FÖR MALMTRANSPORT, A. Thunblom. *Bihang till jernkontorets annaler*, November. 3 pp., 1 fig. *b.*

Description of a *compressed-air locomotive for transportation of ore* built by the Nya Actieboglaget Atlas in Stockholm. The following data were obtained: Consumption of air about 5m.³ per ton-km. ore (109 cu. ft. per ton-

mile); cost of consumed air about 7.5 öre per ton-km. ($0.02 per ton-mile), since 1m.[3] of air compressed to 6 to 7 kg. per cm.[2] (85.2 to 99.4 lb. per sq. in.) cost 1.5 öre ($0.004); the compressed-air locomotive can be conveniently used at a speed of 6 km. (3.7 miles) per hr., but can be driven at 9 to 10 km. (5.6 to 6.2 miles) per hr. on a straight track.

CASE-HARDENING

La cementation du fer par le carbon solide, Charpy and S. Bonnerot. *Revue des métaux et alliages,* November. 1½ pp., 1 table. *C.*

Paper before the French Academy. Guillet and Griffiths have found that *solid carbon* does not produce any *case-hardening* of iron in a vacuum, while Weyl has found that it does. The present authors show that all depends on what degree of vacuum is maintained. When the pressure was under 0.1 mm. of mercury, the iron remained for 38 hours in contact with carbon at a temperature of 950 deg. cent. (1742 deg. fahr.) and no case-hardening occurred, but when the pressure was allowed to reach 0.5 mm., a very clear case-hardening was developed.

CRANES

Mât-grue à rotation totale, P. B. *Portefeuille économique des machines,* November. 5 pp., 13 figs, 3 sheets of drawings. *Ab.*

Description of a *mast-crane* (Louis Perbal and Co. system), arranged to make a complete revolution. The mast carries on its top a slewing crane with a hook for carrying the load, the driver's stand with the lifting gear and motor being placed at about one-third of the height of the mast.

CRUSHING MACHINERY

Groupe de mouture "Orion," M. Bousquet. *Portefuille économique des machines,* November. 1½ pp., 5 figs. *Ab.*

Description of the "*Orion*" *crusher,* consisting of a ball-mill without a sieve and an air separator. The sifting is done in a separate apparatus outside the crusher, and this enables the ball-mill to do an amount of work which formerly, as the author says, would be considered impossible.

FUEL

Le Benzole va Manquer, M. Miguet. *La Pratique automobile,* November 10. ½ p. *b.*

Benzene, being a product of distillation of coal, cannot be counted upon as a fuel for automobiles, owing to its limited output.

Zur Frage der Gasfeuerung in gewerblichen und industriellen Betrieben, Director Förster. *Journal für Gasbeleuchtung,* November. 1 p., 8 curves. *f.*

An investigation made for the design of a packing-house in Mühlheim-Ruhr, Germany, has shown that at a price of 4.3 pfennig per cu. m. ($0.30 per 1000 cu. ft.) *gas is just as economical as coal* for heating two flue boilers of 50 sq. m. (538 sq. ft.) heating surface each, and that even a slight excess of this price would be compensated for by the absence of smoke, soot and dust. Curves show relative cost of coal and gas fuels.

Technic und Industrie auf der Intern. Hygiene-Austellung in Dresden. *Dingler's Polytechnisches Journal*, November 25. *b*.

Lignite briquettes are produced in the following manner by the Verein der Niederlausiter Braunkohlenwerke N-L., Germany. The lignite is first broken by rollers and then ground to powder; the powder, containing 50 per cent to 60 per cent of water, is dried in tube or disc driers, being heated by exhaust steam, until it contains not more than 12 per cent to 15 per cent of moisture, is passed through a sieve and finally submitted to a pressure of about 1500 atmospheres (kg. per $cm.^2$), without the use of any binding substance. The output of a press is about 150 tons of briquettes in 24 hours. By this process the calorific power of the raw lignite equal to 2000 to 2500 W.E. (= 8000 to 10,000 B.t.u. in round figures), is raised to 4700 to 5100 W.E. (= 18,800 to 20,000 B.t.u. in round figures) in the briquettes.

Contre la combustion spontanée des charbons. *L'Echo des mines et de la métallurgie*, November 23. *b*.

Mr. Razous has presented a paper to the French Society for the Advancement of Sciences, in which he recommends the following measures for the *prevention of spontaneous combustion of coal:* (*a*) if coal has to be kept for more than two months, it is well to keep only washed coal; (*b*) if non-washed coal has to be kept, it is a good plan to place in the heaps, at a certain distance from each other, temperature-registering appliances for detecting any rise in temperature; (*c*) if an abnormal rise of temperature is discovered in unwashed coal at the mine, the coal should be washed at once; if the same happens in a manufacturing plant, the heap ought at once to be turned over by shoveling, to reduce the temperature.

GAS PRODUCER

*Fortschritte und Neuerungen auf dem Gebiete der Gasgeneratoren, Gwosdz. *Die Gasmotorentechnik*, November. 3pp., 3 figs. *d*.

Historical sketch of the development of the *gas producer*, mainly with regard to its ability to use cheaper kinds of fuel. Contains a description of the Morton gas producer and the gas producer for suction gas engines of the Société Française de Matériel Agricole et Industriel in Vierson, using for fuel agricultural waste materials such as straw, wood and chips.

INTERNAL-COMBUSTION ENGINES

Les trois cylindres Anzani, type militaire. *L'Aérophile*, November 15. 1 p., 2 figs. *b*.

Description of the new *Anzani 3-cylinder motor* adopted for the military Bleriot airships. The Anzani carburetor is placed above the motor and feeds a gas bag placed at the back of the casing. Into this bag are also led aluminum tubes from the cylinders. The tubes are placed just behind the cylinders in order to protect them from the cold and wind. The lubrication is through the interior of the flywheels and crankpin, by pressure from a pump driven by the motor. The cylinders, pistons and many other parts can be interchanged with corresponding parts of the 6-cylinder Anzani motor, military type.

MITTEILUNGEN DER LUFTSCHIFFBAU ZEPPELIN FRIEDRICHSHAFEN, Graf. v. Zeppelin. *Zeits. für Flugtechnik und Motorluftschiffahrt,* November 11. 6 pp., 17 figs. *b.*

Description of the 150-h.p. *Mayback motor* and methods of testing it.

NOS MOTEURS SONT-ILS PERFECTIBLES? M. d'About. *Technique automobile et aérienne,* November. 2½ pp. *g.*

The progress of metallurgy will help the future designer of internal-combustion engines by supplying him with better materials, but, although the author says that he has seen a motor going without vibrations at 5000 revolutions in a vacuum, he believes that the limits imposed by the limitations of the diameter, lift and number of valves will be impossible to overcome. The increase of efficiency of the engine can be attained by enriching the mixture, but the author does not believe that this can be done by injection of water, as Mr. Patrouilleau tried to show in a paper extensively quoted in this article.

*DIE DIESEL MASCHINE DER MASCHINENFABRIK, J. E. CHRISTOPH ACTIENGESELLSCHAFT IN NIESKY O-L., AUF DER POSENER AUSTELLUNG, 1911. E. Neuberg. *Die Gasmotortechnik,* November. 3 pp., 5 figs. *b.*

Description of the *Diesel engine* manufactured by the above named concern, including an interesting description of the *system of standardization used in the production of the engines.*

*UN MOTEUR ALTERNO-ROTATIF RÉVERSIBLE, F. Carlès. *La Technique automobile et aérienne,* November. 1½ pp., 4 figs. *B.*

Description of a motor invented by Louis Brun in which the *reciprocating motion of the piston is directly transformed into a continuous circular motion.*

LE LAMINAGE DANS LA DISTRIBUTION DES MOTEURS, A. Guéret. *La Technique automobile et aérienne,* October, November. *a.*

The author finds that the *piston engine without poppet valves* (such as the Knight motor) possesses the following *advantages* as compared with the classic type: mechanical and continuous admission without shocks; well balanced valve gear; possibility of using high compressions; higher thermal efficiency, and possibility of using higher speeds of rotation. The disadvantages are: novelty of type; delicate system of lubrication; necessity to take care of possible leakages and expansion.

DREHSCHIEBERMOTOR, J. Lorback. *Der Motorwagen,* November 20. 1 p., 4 figs. *d.*

The author maintains that he has long ago (1904?) not only designed but constructed and used for a whole year on his motorcycle a *rotary slide valve motor.* The drawings in the article refer to a 4-cylinder motor, although the machine actually used had only one cylinder.

*CARBURATEUR SUPPRIMANT LE NIVEAU CONSTANT. *La France automobile et aérienne,* November 18. 1 p., 2 figs. *b.*

Description of Rebourg's *floatless carburetor.*

*LE MOTEUR DA COSTA À CALOTTE DE DISTRIBUTION ROTATIVE. *La Pratique automobile,* November 10. 1½ pp., 1 fig. *b.*

Description of the Da Costa ***motor with a hemispherical cylinder head and a rotary slide valve rotating against it.***

LE MOTEUR KOERTING-DIESEL HORIZONTAL. *Electro*, October. 2½ pp., 3 figs. *b.*

Description of the *Koerting-Diesel horizontal motor.* It is a 4-stroke, single-acting motor, with slow combustion under constant pressure, and amount of fuel introduced in proportion to the power developed. The escaping gases are invisible and without odor. There is no possibility of the motor exploding. As fuel, cheap and slightly inflammable oils are used, such as unrefined mineral oils, shale-oil, mazout and tar-oil from gas works. The thermal efficiency was found to be 34 per cent and the price per horsepower at half load 1.32 centime ($0.25) and at full load 1.12 centime ($0.21).

MACHINE SHOP

VERGLEICH DER COMBINIERTEN WERKZEUGE GEGEN EINFACHE WERKZEUGE IN STANZEREIHEN, M. Beckman. *Zeits. für Electrotechnik und Maschinenbau*, November 23. 1½ pp., 1 fig., 1 table. *a.*

Comparison of general efficiency of *cutting, punching, etc., by one machine, and doing each of these operations by a separate machine.* The first is cheaper, more speedy and gives better results. Schedule form for calculating cost of production with various forms of punching machinery is given.

VERZAHNUNGSPRUEFER, M. Kroll. *Werkstattechnik*, November. 3 pp., 6 figs. *b.*

Description of an *apparatus for testing toothed wheels* indicating the kind, amount and location of irregularities in the teeth and especially adapted for testing wheels running at high speed. The scheme of the apparatus is as follows: Two bodies, each having a toothed wheel attached to it, are driven from the same shaft by two toothed wheels on a shaft. The wheels on the shaft and that on one of the bodies are perfectly cut, while attached to the other body is the wheel under test. If the wheels on both bodies are perfect, the bodies will rotate with an equal speed and a suitably arranged pencil will draw a straight line, while if the wheel under test has some irregularity the bodies will move at that point with unequal speeds and the pencil will draw a wavy line.

*DIE SELBSTSTÄTIGE ZAHNRÄDERSCHLEIFMASCHINE VON MAYER UND SCHMIDT IN OFFENBACH, a. M. Nickel. *Zeits. des Vereines deutscher Ingenieure*, November 25. 2 pp., 2 figs. *b.*

Description of an *automatic machine for grinding toothed wheels.*

NOUVEAU MARTEAU À RESSORT AJAX. *La Métallurgie*, November 29. 1 p., 1 fig. *b.*

Description of the *Ajax spring hammer*, manufactured by Rudolph Schmidt & Co, Düsseldorf, Germany. It is driven by a belt which can be shifted by a belt fork. The shaft placed behind the frame of the hammer

carries at its upper end a heavy flywheel regulating its motion. In the middle of the shaft is placed an eccentric arranged so that its angle of lift can be regulated as desirable, or brought to zero, in such a manner that the big hammers may be used for forging small pieces. In the most recent type the ends of the spring do not pass through an opening in the hammer itself, but through a separate opening covered by a cap cast in one piece with the hammer. This makes the hammer stronger and prevents rupture at that point. On this cap is placed a lubricator cap which insures better lubrication and makes the wear at the opening less rapid. The anvil is not cast in one piece with the anvil-block, but is attached to it by four long bolts.

Die moderne Schleif-und Polierwerkstatt, Eugen Werner. *Werkstattstechnik*, November. 5 pp., 1 fig. *b.*

Description of a *German modern grinding and polishing shop*, with data on installation costs and the cost of using various polishing materials.

MATERIALS OF CONSTRUCTION AND TESTING OF MATERIALS

Ueber den Zuverlässigkeitsgrad von Festigkeitsversuchen, A. Martens. *Mitteilungen aus dem Königlichen Materialprüfungsamt zu Gross-Lichterfelde West*, Vols. 5 and 6, 1911. 95 pp., 3 figs, over 80 pp. of tables. *Ah.*

A. Martens, who is the director of the Prussian Royal Laboratory for the Testing of Materials of Construction, and author of an important book on that subject, discusses *methods of selecting reliable values for the strength of materials* from among several values obtained in different tests, or by different testing laboratories.

L'Aphégraphe, M. R. Guillery. *Mémoires de la Société des Ingénieurs Civils de France*, August. 15 pp., 8 figs.,1 plate of photoengravings. *b.*

Description of two new *apparatus for testing the strength of materials:* (*a*) a dynamometric ram impact machine the purpose of which is to break, by bending by shock, at a convenient speed, a notched test piece of a type defined by the last convention of the International Society of Methods of Testing, and to measure the amount of work required for this fracture; (*b*) the Aphegraphe for tracing curves representing such values as the stress during the shock in the bending test, inertia stresses in certain machines, resistances of railway trains, as a function of velocity, etc.

Priblishenni sposob roslidu zignutya shtab, Prof. Stephan Timoshenko. *Proceedings of the Technical Section of the Ukrainian Scientific Society of Kieff*. 38 pp., 7 figs. *c.*

An *approximate method of solving problems on bending of bars* without integration of differential equations.

Maschinenfundamente aus Eisenbeton, E. Elwitz. *Zeits. für Dampfkessel und Maschinenbetriebe*, November 23. 2pp., 20 figs. *b.*

A brief description of an improved method of the construction of *reinforced concrete foundations for machinery*, with detailed drawings. The improvement consists in laying an upper and lower round iron grating in the foundation. The article and drawings appeared in *Beton und Eisen*, October 25.

NOUVEAU PROCÉDÉ DE LA CONSTRUCTION EN BÉTON-ARMÉ, P. Braive. *La Technique moderne*, November. 2 pp., 3 figs. *b.*

Description of the *Monnoyer & Son method of reinforced concrete construction*, used mainly for constructing vertical walls, smoke-stacks, etc. In this method concrete blocks are used in such a size and form that when put together they give a resistance suitable for the given construction, and, at the same time, enclose between them the reinforcing elements. The article indicates the methods of calculation required in the construction of smokestacks, according to the French regulations for the use of reinforced concrete.

MECHANICS

VERSUCHE UEBER DIE SCHWINGUNGEN VON KARDANWELLEN, Th. Lehmbeck. *Zeits. des Mitteleuropäischen Motorwagen-Vereins*, Mid-November. 3 pp., 3 figs. *c.*

Experimental investigation of *oscillations in Cardan shafts*. The following practical results were obtained: If the setting of the Cardan shaft is as close to the ends as possible, Stodola's equation can be used for the computation of the critical number of revolutions. The longer the ends of the Cardan shaft are beyond the ball-bearings the greater the oscillations and power losses. Stodola's equation (Die Dampfturbinen, 1905, p. 197) is: the critical number of revolutions $N_k = \frac{r\,10^6}{L^2 1.633}$, where r is the radius of the shaft and L is one-half the distance between the centers of the ball-bearings, both in centimeters. It is further extremely important that the shaft be turned perfectly true, because the slightest deviation leads to a rapid growth in the amplitude of oscillations, and results in a total destruction of the ball-bearings. No Cardan shaft should be made of tubing, because, even with truest turning, it is never so uniform as to prevent the rise of centrifugal forces which produce oscillations, and will lead to an instant breakdown should these oscillations coincide with the critical number of revolutions.

PUMPS

GASPUMPEN UND KOMPRESSOREN, Dierfeld. *Elecktrische Kraftbetriebe und Bahnen*, November 27. 5½ pp., 13 figs. *b.*

A description of the latest type of the *Humphrey gas pump*, based on materials communicated by the inventor, Mr. Humphrey, and a discussion of its characteristics and industrial possibilities. (See also Practical Engineer and Engineer's Gazette, London, August 4, 1911, The Humphrey Internal-Combustion Pumps.) Article to be continued.

*DER HYDROPULSOR, EINE NEUE HYDRAULISCHE SCHÖPFMASCHINE. *Prometheus*, November 11. 5½ pp., 8 figs. *b.*

Description of a *new hydraulic pump* constructed on the principle of Mongolier's hydraulic ram, but having instead of two poppet valves one rotary valve working without shocks and thus permitting the construction of large units.

REFRIGERATING MACHINERY

Nehemia Kältemaschinen. *Haustechnische Rundschau*, November. $^3/_4$ p., 1 fig. *b*.

Description of the *Nehemia refrigerating machine* of Metallwerke Neheim Co., Neheim-Ruhr, Germany. This machine uses, for small units, carbon dioxide taken from the evaporator and compressed in the condenser, where it becomes liquid under the influence of pressure and cooling water. The liquid carbon dioxide passes then through a regulating valve back into the evaporator, where it is evaporated and thereby lowers the temperature of the surrounding space. The consumption of CO_2 is slight. A special ventilating arrangement helps to keep the air in the room clear and dry.

*Das Problem der Tiefkühlung, Privatdocent Rud. Plank. *Zeits. für die gesammte Kälte-Industrie*, October, November. 9 pp., 2 diagrams. *h*.

Discussion of materials to be used in *refrigerating machinery for low temperatures* (—76 to —112 deg. fahr.), with data on N_2O. Pressure-volume diagram of N_2O and temperature-entropy diagram are given.

SAFETY APPLIANCES

Schutzbrillen fuer autogene Schweiszung. *Zeits. für Sauerstoff und Stickstoff Industrie*, November 1911. 3 figs. *b*.

Description of *protective appliances* of the firm J. Seipp, Frankfurt a. M., Eschersheim: (*a*) spectacles for autogenous welding, which are held in place by a leather strap without producing any unpleasant pressure on the head, and in which the glasses are fixed, not in a wire frame, but in a rubber band arranged in a way to protect the eyes from sparks and particles of molten metals; (*b*) mask for use in autogenous welding of metals producing poisonous gases, e. g. aluminum, with protective eyeglasses, and a respirator device in which the entering air passes through a special rubber pipe, while the outgoing air has a free passage through a valve which lets the air out but not in; (*c*) a respirator arranged as above but without the protective eyeglasses.

Manivelle de sureté, pour appareils de levage et moteurs à explosion. *Le Génie Civil*, November 25. 1 p., 7 figs. *Ab*.

Description of three types of *safety starting handles* for elevators and explosion motors which received the prize at the international competition of the French Manufacturers' Association for the prevention of accidents to employees.

STEAM ENGINEERING

Sur le tirage rationnel des générateurs de vapeur, J. Izart. *La Technique moderne*, November. 3 pp., 8 figs. *b*.

Discussion of *natural* (by smokestack) *and artificial* (by blowers) *draft* for steam generators. Natural draft is unsatisfactory, because a brick stack is not economical, is inefficient, and lacks in elasticity in the production of partial vacuum. With a steel stack the friction is less but the economy is still poor. The use of blowers is not a rational method of draft either, because it is as uneconomical as natural draft, and in addition consumes a considerable amount of power. The article is to be continued.

LE CHAUFFAGE ÉCONOMIQUE DES CHAUDIÈRES, PROCÉDÉ WILTON. *Fer et Acier*, October. 3½ pp., 3 figs. *b.*

Description of the *Wilton process of firing boilers*, claimed to be very economical and efficient.

UEBER DIE HÖHE DES PROBEDRUCKES VON DAMPFESSELN. *Braunkohle*, November 24. 1 p. *A.*

Article from the *Zeits. der Dampkesseluntersuchung und Versicherungsgesellschaft.* Inspector Fritz Kraus of Vienna discusses the *reasonable hydraulic pressure to which a boiler ought to be subjected during tests for strength.* In 1902 some French engineers tried to show by statistics that the high pressures to which boilers were subjected during hydraulic tests (twice as high as the maximum working pressure) lowered the resisting power of the boilers. Professor von Bach found in 1906 that hydraulic tests are sometimes likely to give doubtful results. The author thinks that a pressure equal to only one and one-half that of the ordinary working pressure ought to be applied in hydraulic tests.

DIE WEITERE ENTWICKLUNG DER GLEICHSTROMDAMPFMACHINE, Bol. *Electrotechnische Zeits.*, November 23. ²/₃ p., 2 diagrams. *b.*

Extracts from paper by Professor Stumpf at the meeting of the Society of Marine Engineers (German), on the latest developments in the design of the *straight flow steam engine.* It has been found that, with a carefully designed heating of the cylinder walls, this type of machine can work with saturated steam as economically as with superheated. The designers have also succeeded in reducing from 2 per cent to 4 per cent the clearance in engines having the exhaust into the air or a higher back pressure, this being attained by placing a special valve in the piston.

*PETRY-DEREUX GROSSWASSERRAUM-WASSERROHR-DAMPFKESSEL. *Der Practische Maschinen-Konstrukteur*, November 23. 1½ pp., 35 figs. *b.*

Description of the *Petry-Dereux* (Düren, Germany) water-tube boiler with large water space, and its traveling grate, more fully described on a following page.

CALCUL DE LA SURFACE DE CHAUFFE DES TUBES FOYERS TYPE FOX, Noël Dessard. *Annales des mines de Belgique*, Vol. 6, Pt. 4. 6 pp., 2 figs. *c.*

Analytical method of *calculating the heating surface of Fox flues*, giving a formula which can be applied in practice without the use of a term of compensation for errors.

*L'ELECTRICITÉ ET LA MÉCANIQUE À L'EXPOSITION DE CHARLEROI, D. Verden. *Electro, October.* 2½ pp., 3 figs. *b.*

Contains a description of the *Electra low-power turbine* using low-pressure steam from the exhaust of other machines, steam hammers, etc., or simultaneously, low-pressure steam from the exhaust and live steam from a boiler.

*DIE WÄRMEKRAFTMASCHINEN AUF DER OSTDEUTSCHEN AUSSTELLUNG POSEN, 1911, Prof. H. Baer. *Zeit. des Vereines deutscher Ingenieure*, November 25. 12 pp., 44 figs. *B.*

Description of *heat engines and turbines* at the East German Exhibition in Posen, 1911. A fuller description of a 1200-h.p. twin-tandem engine of the Maschinenbau Co., Hirschberg, is given on a following page.

DER EINFLUSZ DES HEISZDAMPFES AUF DIE AUSGESTALTUNG DER DAMPFMASCHINEN, LOKOMOBILEN, LOKOMOTIVEN UND SCHIFFMASCHINEN, H. Lentz. *Zeits. des Oesterr. Ingenieur und Architekten Vereines*, November. 5 pp., 38 figs. *Abc.*

The practice of several German firms, e.g. Lanz in Mannheim, has shown that in a properly designed steam engine the *consumption of heat* falls as the degree of superheat rises. A 300-h.p. stationary steam engine has been constructed with a consumption of heat closely approaching that of a Diesel motor. Similar engines for the propulsion of ships have also been designed.

THERMODYNAMICS

UEBER DIE GRUNDLAGEN DER MECHANISCHEN THEORIE DER WÄRME, F. Hasenöhrl. *Physicalische Zeits.*, November. 4½ pp., 2 curves. *Ac.*

Planck introduced his formula for the *calculation of energy and entropy* of an oscillation instead of the classical formula, $e^{-\frac{J}{\theta}} = \int_0^\infty d\, V e^{-\frac{E}{\theta}}$ in order to avoid the so-called equipartition of energy. Planck's formula was, however, intended for a resonator having purely harmonic oscillations, the number of oscillations being independent of the energy. Hasenöhrl shows that if the period of oscillation τ is a function of the energy τ (E), if E has such values that the values of τ do not form a continuous series, and if $\frac{dv}{dE}$ = constant C, then the differences between the successive numbers of oscillations form an arithmetical series (in accordance with the first law of spectra of Deslandres) and, further, such a relation of energy and period of vibrations may be found that the series of possible numbers of oscillations correspond to Balmer's formula ($\tau_m = A \frac{m^2}{m^2-4}$) for the series of spectral lines of hydrogen.

WELDING

NEUE ARBEITSMETHODEN DER AUTOGENEN SCHWEISS UND SCHNEIDVERFAHREN ACETYLEN, No. 20, Theo. Kautny. 1½ pp. *b.*

Description of the *course of instruction* given *in autogenous welding* at the Royal School of Machine Construction in Cologne, Germany. The course lasts three weeks, of which one is devoted to theoretical instruction and two to practical work. Fee, 40M (about $10). The course is open to foreigners and is attended mainly by manufacturers and engineers. There are a well appointed laboratory and shops where the practice of autogenous welding may be studied. Principal attention is paid to welding by acetylene. Article to be continued.

MISCELLANEOUS

PHOTOGRAPHIEREN OHNE CAMERA, Carl von Arnhard. *Zeits. für Electrotechnik und Maschinenbau*, November 23. 1 p., 1 fig. *b.*

Drawings, pictures, tables, etc., *may be reproduced from printed originals* (even from books) by placing a sensitive plate (yellow gelatine appears to be the most suitable) on the side opposite that containing the picture to be photographed, and then exposing the picture to the light of a specially constructed electric lantern for about 12 seconds, the lantern being at a distance of about 15 cm. (6 in.) from the picture. Drawings printed on one side of the paper are reproduced especially well.

*EIN NEUER FLUESSIGKEITSZERSTÄUBER, Gwosdz. *Glückauf*, November 25. $^2/_3$ p., 1 fig. *b*.

Description of a *turbine-driven liquid sprayer* rotating at 12,000 r. p. m.

GUMMI-RIEMEN UND SEILE.. *Gummi-Zeitung*, November 24. 1 p. *a*.

The article claims that *rubber belts and ropes* are better than leather belts and hemp ropes. A rubber belt is said to last longer, to run true even after a long use, and to be less affected by moisture and acid vapors than a leather belt.

RELATIVITETSPRINCIPET, V. Isaachsen. *Electroteckniak Tidskrift*, November 18. 2 pp. *c*.

A popular exposition of the *principle of relativity*. Article to be continued.

ABSTRACTS OF ARTICLES

LE MOTEUR DA COSTA À CALOTTE DE DISTRIBUTION ROTATIVE. *La Pratique automobile*, November 10.

The Da Costa motor has a valve gear consisting of a rotary valve and a hemispherical cylinder head, both being provided with special segments

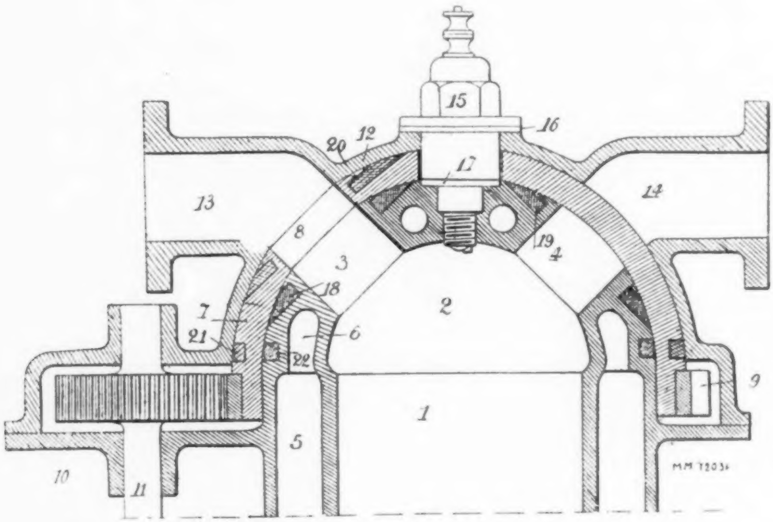
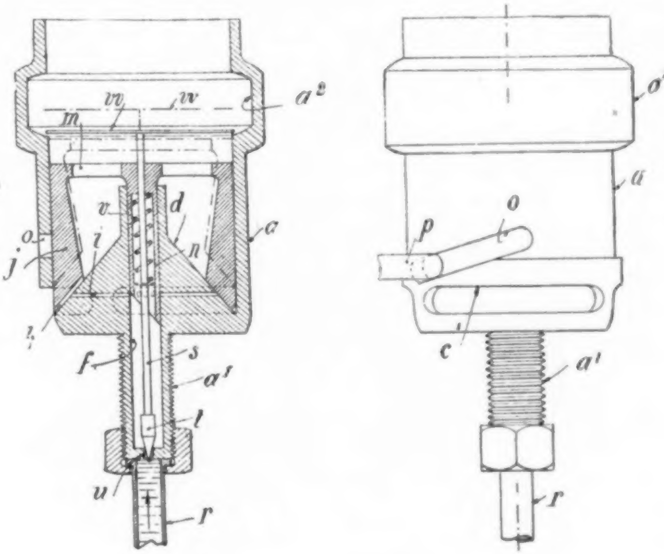


FIG. 1 DA COSTA HEMISPHERICAL ROTARY SLIDE VALVE MOTOR

insuring tightness of fit. In Fig. 1 the working cylinder 1 has a hemispherical cylinder head 2 with openings 3 and 4. The cooling jacket 5 around the cylinder 1 extends (6) into the interior of the wall of the cylinder head 2. On the cylinder head is freely set the rotary valve 7, also hemispherical, with an opening 8, which passes over the openings 3 and 4 during the rotation of the valve. The rotary motion is transmitted to the valve from the engineshaft by the shaft 11 (moving at the same speed as the engineshaft) through a pinion 10 and a gear wheel *g*. On the rotary valve 7 is placed the back cylinder cover 12, provided with passages: 13, leading to the carburetor, and 14, to the muffler. In the upper part of the back cylinder cover is a circular opening corresponding to the openings in the rotary valve and the cylinder head for the spark plug 15, a tight fit being provided by the packing 16 and 17. The function of the valve gear is as follows: The pinion 10 gives to the valve 7 a rotary

motion, which brings the opening 8 either between 3 and 13 (admission) or between 4 and 14 (exhaust). When the opening 8 is in neither of these positions, the combustion chamber is completely closed, as is required for the periods of compression, explosion and expansion. The valve 7 rotates at half the speed of the engineshaft.

CARBURATEUR SUPPRIMANT LE NIVEAU CONSTANT. *La France automobile et aérienne*, November 18.



FIGS. 2 AND 3 REBOURG FLOATLESS CARBURETOR

This carburetor has a needle *t* (Fig. 2) actuated by a spring in a manner such that it closes the passage of the liquid when the carburetor is at rest, and when the carburetor has to begin to act opens it automatically under the influence of the suction of the motor. This allows the carburetor to act in any position whatever, and does away with the float chamber. The carburetor (Figs. 2 and 3) consists of a cylinder *a* with three side openings *c* for the admission of air and is connected by the pipe *r* directly with the fuel, i. e., with no float chamber between. The tank is placed in a way such that the liquid tends to rise in a^1 and in the vertical passage *f* bored in the conical cap *d* on the cylinder cover. Into the channel *f* lead three slots *i* made in *d*, radially, in the same plane, from the surface inward. In the channel *f* moves, with a slight friction, a tubular piston *n* with an "edge shaped" lower end, the piston ordinarily occupying such a position that only one of the three slots *i* is open. Inside the piston *n* moves freely the stem *s* of the needle *t*, which ordinarily keeps closed the opening *u* in the lower extremity of a^1, the needle being kept down by the helical spring *v*. The stem of the needle has, at its upper

end, a disc w placed in such a manner that when the needle is down it nearly comes in contact with the walls of the cylinder a and so closes it nearly completely. In the cylinder a there is a ring-shaped groove a^2, placed so that when the disc w is raised by the suction of the motor (as shown by the broken line, and as happens when the needle t opens the orifice u) there is a free passage around it. The piston n is connected by a cross-head m with the bush j, moving vertically inside the cylinder a and having the lower part cut off conically so as to fit exactly d. In this lower part a groove k is cut in a way such that when j is completely down, the external air can pass through this groove into the carburetor. Into the groove k leads that of the three slots i, which is ordinarily left open by the piston n. In the cylinder a is cut an inclined slit o in which moves a stop-pin with a hand lever at its other end. When the motor is at rest the needle t is kept down by its spring and no fuel can pass. As soon as the suction of the motor begins, the disc w rises and the needle allows the fuel to come into a^1. If the bush j is kept down, the fuel can pass only through the one open slot i into the groove k, where it is drawn in by the current of air sucked in. That corresponds to the slow working of the motor. For the normal working of the motor, the bush j and the piston n are raised by the hand lever and passages are opened for the air between j and d and for the fuel through all the three slots i, the arrangements being such that the supply of air is in the right proportion to the supply of fuel.

Forschritte und Neuerengen auf dem Gebiete der Gasgeneratoren. (The Gas Producer of the Société Française de Matérial Agricole et Industriel), Gwosdz. *Die Gasmotorentechnik*, November.

The producer shaft has a sheet-iron jacket. From the hopper (Fig. 4) B a feeding hopper covered by the valve D branches out sidewise. The shaft rests on the ash pan F, closed air-tight and separated from the shaft by the grate G. The upper part of the shaft jacket is connected with a pipe V going down to the ash pan F and having a branch pipe P coming axially into the producer shaft. At various heights a number of holes are bored through the shaft walls and its jacket, these holes acting as auxiliary air-ducts. In the pipe V leading to the ash pan is situated a fan Y for increasing the draft. The pipe H connects the ash pan with the water seal I of the scrubber J in its turn connected with the sawdust-purifier N. The installation of several rows of air-ducts at various heights allows the use of the producer for various kinds of fuels. For more compactly laid fuels the lower rows of air-ducts are used. Experience has shown that in this producer a gas poor in tar can be obtained from bituminous fuel.

Die Deisel-Maschine der Maschinenfabrik J. E. Christoph A. G., Niesky, O-L., Germany, Ernst Neuberg. *Die Gasmotorentechnik*, November.

What kind of Diesel engine should a factory build, vertical or horizontal? For the supply of stationary plants the horizontal engine has the following advantages: lower cost of production; easier repairs of the piston; absence of galleries and stairs; lesser height of the power house; more

convenient arrangement of the exhaust pipes. On the other hand, in building vertical engines the factory can build many units with a small number of patterns, and on account of the small number of patterns, can attain the highest degree of mass production.

The J. E. Christoph Company builds motors of three patterns only: 30 h.p., 65 h.p. and 100 h.p., and from these three patterns the following types are built:

One Cylinder H.P.	Two Cylinders H.P.	Three Cylinders H.P.	Four Cylinders H.P.
30	60	—	—
65	130	200	260
100	200	300	400

By increasing or decreasing the number of revolutions the factory, with

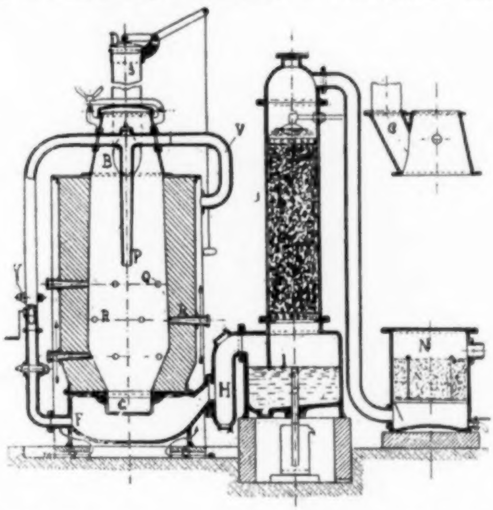


FIG. 4 GAS PRODUCER USING AGRICULTURAL WASTE AS FUEL

these ten types, can fill orders for any machine from 30 to 400 h.p., and what is more important, can produce the cylinders cheaply by making 15 to 25 of each pattern at once. The standardization of the production of all the other machine parts, as far as it is possible, allow their cheaper production, and decreases the amount of parts in stock kept by the agents of the company. The following methods are used to standardize the production of bearings: The middle and outer undivided bearings are made of equal dimensions, and the divided bearings of the spiral gear for the one and two-cylinder motors are made of symmetrical halves, allowing a pattern to be used more than once. In the three and four-cylinder motors one of the braces is made broader to provide for possible heavier stresses. The air-compressor is separate from the main body of the machine, which does away with the connecting rod or crank-driving mechanism, and allows the compressor to be driven by a belt or to be directly

connected to the shaft, the belt arrangement having the further advantage that the number of revolutions and output of the compressor can be widely varied by a simple change of the belt pulleys, independently of the motor. To avoid excessive clearances the piston heads of the compressor are made concave, and the non-mechanically operated valves are placed at an angle to the axis of the cylinder.

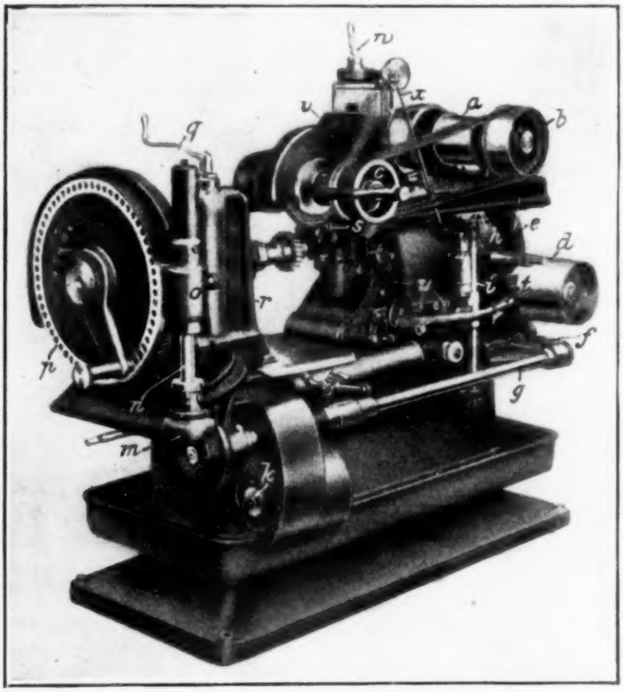


Fig. 5 Automatic Machine for grinding Toothed Wheels

Die selbststätige Zahnräderschleifmaschine von Mayer & Schmidt in Offenbach a. M. Nickel. *Zeits. des Vereines deutscher Ingenieure*, November 25.

The automatic machine for grinding toothed wheels of this type grinds at once the whole surface of a tooth space, and acts like a milling cutter. The grinding wheel, which has the same form as the tooth space to be ground, is set on the front end of a ram-like slide having a reciprocating motion. It is driven by the belt *a* (Fig. 5) and pulleys *b* and *c*, the spindle going at 1700 r. p. m. The reciprocating motion of the slide, making ten double strokes per minute, is transmitted to it from the fixed pulley *d*, which is provided with a belt shifter and is driven from an overhead countershaft.

In this process the grinding disc will change its form after every few strokes, to a certain extent after every single stroke, and such a change might affect the true shape of the teeth ground. The machine has a device (very imperfectly shown in the figure) for keeping the disc in its original shape, consisting of three diamonds which, when placed on a special gage, run along the sides and periphery of the disc. The gage is placed at *s* and is regulated either by hand, by the handle *t*, or automatically by the shaft *i* and rod *u*, in which case the gage is made use of during the operation of the dividing mechanism. If the automatic regulation is used, the same arrangement takes care of the disc after each reciprocating motion

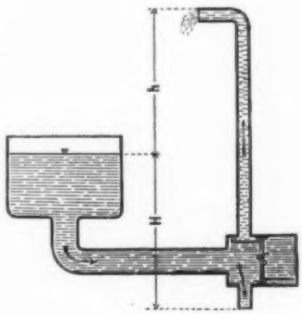


FIG. 6 HYDROPULSOR

of the slide. Since, however, the wear of the grinding disc after a single stroke is really very insignificant, the regulating device is not left in action all the time, but is used only at the end of a full revolution, being locked out the rest of the time by displacing the rod *u*. The number of discs required for this machine is comparatively small, because, for each kind of tooth space, a special gage and not a special disk, is required. The use of the diamonds and gage, which are the important elements of this machine, are not adequately described in the article.

DER HYDROPULSOR. *Prometheus*, November 11. (Cp. *Zeits. des Vereines deutscher Ingenieure*, February 18, 1911.)

The Hydropulsor (sometimes called Hydropulsator) is a pump based on the principle of Montgolfier's hydraulic ram. The ram, however, could be used only for small amounts of water because the repeated shocks were apt to destroy the poppet valves very rapidly. The Hydropulsor, invented by A. Abraham and constructed by the Ottenser Eisenwerk Company, Altona, Germany, uses a rotary valve instead of poppet valves, thus permitting the apparatus to be built in any size. The arrangements of the parts is shown in Fig. 6. The water under pressure flows downward through the discharge pipe, but when it acquires certain efflux velocity the rotary valve is set in motion by the water, closes the discharge pipe,

and at the same time opens the delivery pipe into which the water is driven. The rotating valve then closes the delivery pipe and opens the discharge pipe, thus allowing the mass of water to gain a certain accel-

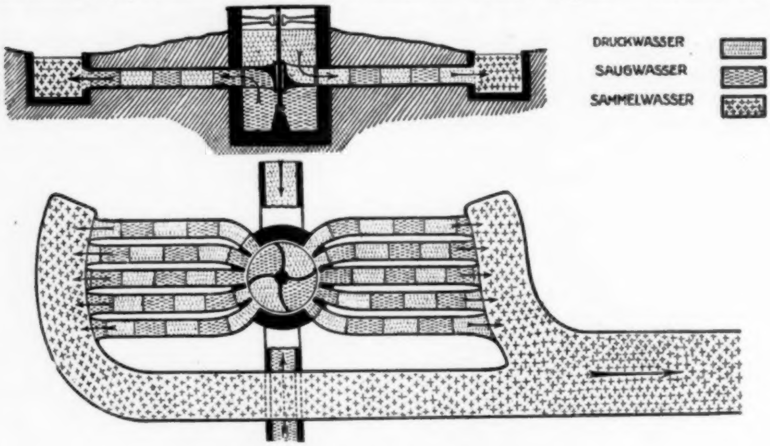


FIG. 7 HYDROPULSOR IN A WELL

Druckwasser (water under pressure); Saugwasser (water under suction); Sammelwasser (collector)

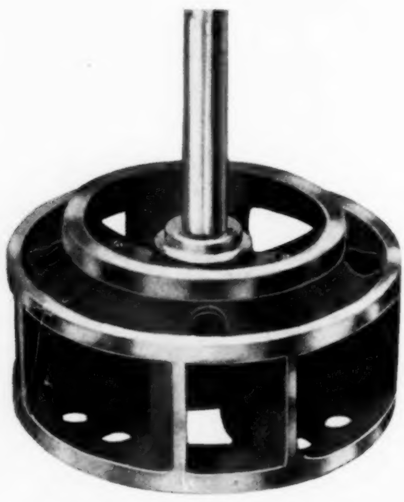


FIG. 8 HYDROPULSOR VALVE

eration. Since it is possible to place several delivery pipes and as many discharge pipes around the valve, large amounts of water can be lifted by a machine of moderate size. The practical arrangement of such a

system is shown in Fig. 7. The rotary valve (Fig. 8) is placed in the well on a vertical shaft in such a manner that it divides the well into an upper water space (water under pressure) and a lower (water under suction). The delivery pipes (in Fig. 7, five on each side of the valves) are led to the collectors from the rotary valve. When the water under pressure reaches the upper part of the well space it must then pass into the water pressure chambers of the valve, which open upward, and from them into the delivery pipe. But since the walls of the chambers of the valve are curved like turbine vanes, the passage of water sets the valve into rotation and this results in the delivery pipes being alternately connected, first with the upper part of the water (under pressure) and then with the lower part of the water (under suction). But when a delivery pipe is cut off from the water under pressure by the rotation of the valve, the water in it continues to flow for some time under the action of inertia, and by the time the delivery pipe comes above the lower mass of water, a vacuum is formed in it, into which the water is drawn from below. Before this suction has time to cease and a backward flow begins the rotation of the valve brings the delivery pipe opposite that part of the water under pressure, and the whole cycle recommences. A hydropulsor has been constructed to use the power of the tides, and is claimed to work satisfactorily.

Das Problem der Tiefkuehlung, Rud Planck. *Zeits. für die gesammte Kälte-Industrie*, October, November.

Some mining and chemical industries have lately created a demand for refrigerating machinery giving a temperature of —60 to —80 deg. cent. (—76 to —112 deg. fahr.). NH_3 and SO_2 are inconvenient for such temperatures because they have deep pressure-volume curves; their saturated vapors are, even at a temperature of —76 deg fahr., present in strong vacuum, and it is very difficult to work with such a vacuum for any length of time. CO_2 cannot be used because it solidifies at —56 deg. cent. (—67 deg. fahr.), and experiments of using Pictet's mixture (CO_2 and SO_2) proved to be equally unsuccessful. The cold air engine, as shown lately by the experiments of Lorenz, is uneconomical owing to the large piston surface of the compression cylinder required. The only suitable material seems to be N_2O (laughing gas). The author describes its physical properties and gives its pressure-volume curve, as well as a table of its properties (Table 1).

Petry-Dereux Groszwasserraum-Wasserrohr-Dampfkessel (The Petry-Dereux traveling grate). *Der Praktische Maschinen-Konstrukteur*, November 23.

Chain grates necessitate frequent and expensive repairs owing to their separate parts, bolts, etc., being rapidly destroyed by their exposure to the action of the fire. To avoid this the chains and bolts in the Petry-Dereux traveling grate (Fig. 9) are placed far below the fire line, and therefore not subjected to the direct action of the fire. This grate can be used for such kinds of coal for which the chain grate is not suited, and grate bars can be changed without stopping the work of the boiler.

TABLE 1 PROPERTIES OF N_2O

$R = 19.28$ $\mu = 44$

Temperature $t°$ Cent. / Fahr.	Temperature $T°$ Absolute Cent. / Fahr.	Pressure p Atmospheres Kg. per Sq.Cm. / Lb. per Sq. In.	Specific Volume, Liquid v' Cu. M. per Kg. / Cu. Ft. per Lb.	Specific Volume, Steam v'' Cu. M. per Kg. / Cu. Ft. per Lb.	Weight of 1 Cu.M. Steam γ'' Kg. per Cu. M. / Lb. per Cu. Ft.	Internal Heat of Evaporation ρ W. E. / B.t.u.	External Heat of Evaporation $AP(v'' - v')$ W. E. / B.t.u.	Total Heat of Evaporation r W. E. / B.t.u.
36.4	309.4	75	0.00255	0.00255	392.0	0	0	0
97.6	524	1065	0.04080	0.04080	24.5	0	0	0
36	309	74.3	0.00218	0.00336	376.0	6.5	0.83	7.3
96.8	523.2	1055	0.03498	0.05376	23.5	25.8	3.28	29.
35	308	72.7	0.00196	0.00334(?)	299.5	11.2	2.35	13.5
95	522.4	1035	0.03136	0.05344(?)	18.7	44.4	9.32	53.6
30	303	65.55	0.00160	0.00452	221.3	23.9	4.5	28.4
86	513.4	930	0.0256	0.07262	13.8	95	17.7	112.5
25	298	58.80	0.00144	0.00560	178.7	31.5	5.7	37.2
77	504.4	832	0.02300	0.08960	11.2	125	22.3	147.5
20	293	52.55	0.00134	0.00673	148.7	37.05	6.65	43.7
68	405.4	745	0.0214	0.1076	9.3	147	26.3	173.
15	288	46.8	0.00126	0.00797	125.5	41.65	7.35	48.0
59	486.4	663	0.02016	0.1276	7.8	165	29.2	194.5
10	283	41.75	0.00120	0.00936	106.9	45.2	8.0	53.2
50	477.4	592	0.01920	0.1496	6.65	179	32.8	211.4
5	278	37.22	0.00115	0.01090	91.8	48.3	8.5	56.8
41	468.4	528	0.01845	0.1744	5.7	192	33.7	225
0	273	33.28	0.00111	0.01261	79.3	50.7	9.0	59.7
32	459.4	471	0.01776	0.2017	4.95	200	35.7	234.9
−5	268	29.73	0.00108	0.01461	68.5	52.8	9.4	62.2
23	450.4	422	0.01728	0.234	4.25	211	37.3	247
−10	263	26.50	0.00105	0.01680	59.5	55.15	9.75	64.9
14	441.4	375	0.01680	0.269	3.7	219	38.7	257.
−15	258	23.53	0.00102	0.01924	52.0	57.3	10.1	67.4
5	432.4	333	0.01632	0.3080	3.25	227	40.1	267
−20	253	20.70	0.00100	0.02170	46.1	59.3	10.3	69.6
−4	423.4	295	0.01600	0.347	2.85	235	40.9	276
−25	248	18.09	0.00098	0.02465	40.6	61.5	10.1	71.6
−13	414.4	257	0.01568	0.395	2.5	244	40.1	284
−30	243	15.70	0.00096	0.02770	36.1	63.6	9.9	73.5
−22	405.4	223	0.01536	0.443	2.25	252	39.6	292
−35	238	13.40	0.00094	0.0320	31.3	65.6	9.8	75.4
−31	396.4	190	0.01504	0.512	1.95	260	38.9	299
−40	233	11.30	0.00093	0.0375	26.7	67.6	9.7	77.3
−40	387.4	160	0.01472	0.600	1.65	268	38.5	306
−45	228	9.55	0.00091	0.0436	22.95	69.5	9.6	79.1
−49	378.4	135	0.01440	0.696	1.4	276	38.1	314
−50	223	7.94	0.00090	0.0517	19.35	71.5	9.5	81.0
−58	369.4	113	0.01408	0.827	1.2	284	37.7	321
−55	218	6.50	0.00088	0.0624	16.04	73.4	9.4	82.8
−67	360.4	92.3	0.01376	0.999	1.	291	37.3	328
−60	213	5.28	0.00087	0.0759	13.18	75.4	9.3	84.7
−76	351.4	75	0.01344	1.22	0.82	299	36.9	336
−65	208	4.20	0.00085	0.0942	10.62	77.3	9.2	86.5
−85	342.4	59.6	0.01312	1.51	0.66	307	36.5	343.5
−70	203	3.32	0.00084	0.1176	8.51	79.2	9.1	88.3
−94	333.4	47.3	0.01296	1.88	0.53	314	36.1	350
−75	198	2.50	0.00083	0.1550	6.46	81.2	9.0	90.2
−103	324.4	35.5	0.01280	2.48	0.40	322	35.7	358
−80	193	1.90	0.00082	0.2038	4.91	83.1	8.9	92.0
−112	315.4	26.8	0.01264	3.26	0.30	330	35.3	365
−85	188	1.38	0.00081	0.2728	3.67	85.1	8.8	93.9
−121	306.4	19.6	0.01248	4.37	0.23	338	34.9	371.5
−90	183	1.00	0.00080	0.3712	2.70	87.0	8.7	95.7
−130	297.4	14.2	0.01232	5.94	0.165	346	34.5	379.9

Die Wärmekraftmaschinen auf der Ostdeutschen Ausstellung Posen, Maschinenbau A. G., Hirschberg, Germany. *Zeits. des Vereines deutscher Ingenieure*, November 25.

The engine (Figs. 10-14) has the diameter of the high-pressure cylinder 510 mm. (20 in.), the diameter of the low-pressure cylinder 800 mm. (31.5 in.), and stroke 800 mm. (31.5 in.). In the middle is placed a rope-

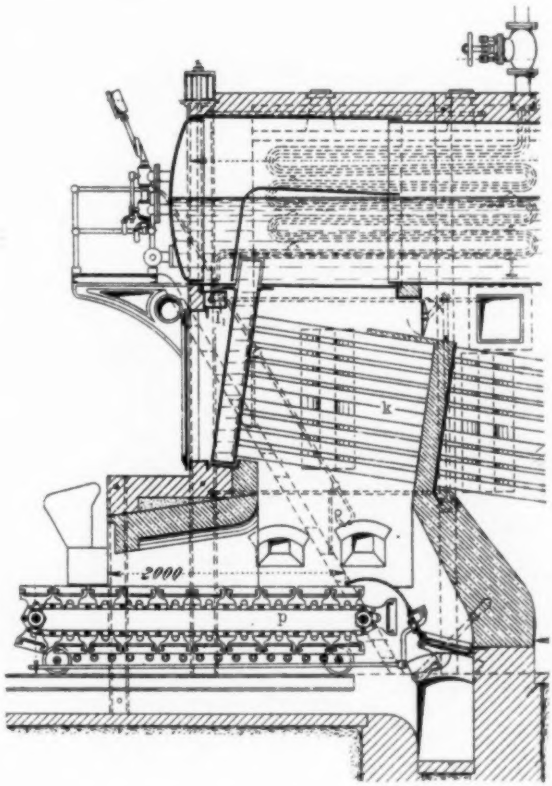


Fig. 9 Petry-Dereux Traveling Grate

pulley flywheel, 4000 mm. (157.48 in.) in diameter, with grooves for 24 ropes 50 mm. (1.9 in.) thick. The shaft is provided on both ends with overhung cranks working tandem fashion, with the high and low pressure cylinders. Each side of the engine has its own condensation by injection with a 2-cylinder double-stage wet air pump. The engine has the following noteworthy peculiarities of construction: Both the high and low-pressure cylinders are provided with so-called stream-covers; the live steam comes into the cover through a connecting branch in the cylinder, and passes through it into a passage leading to the inlet valve. As a result, the cylinder covers are heated to a high degree, with a view to reducing

the heat losses. The pistons are ground in the cylinder in the lower third of the periphery; this insures a proper guiding of the piston rods without producing any serious pressures in the guiding surface of the pistons. The low-pressure side has, besides the cover heating, also a heating of cylinder walls by receiver steam. In order to avoid heat losses the water of condensation from the walls of the low-pressure cylinder and the receivers is driven by a small pump to the superheaters in the boiler plant. The governor is not placed on top, near the high pressure cylinder, as usually, but down below in the foundation, in a cast-iron casing. With a pressure of 12 atmospheres above atmospheric, and a temperature of 350 deg. cent. (662 deg. fahr.) the engine gives at 130 r.p.m. about 1200 i.h.p., or 1100 effective h.p.

EIN NEUER FLUESSIGKEITSZERSTÄUBER, Gwosdz. *Glückauf*, November 25.

Besides nozzle-sprayers, a new type of sprayers has come into use in which the liquid is atomized by rapidly revolving discs. These sprayers

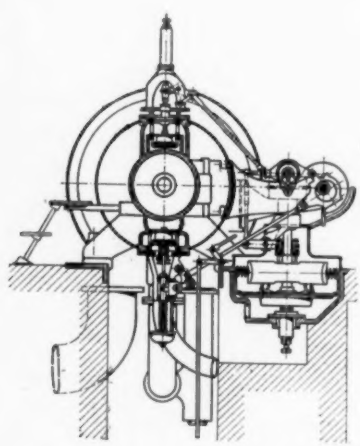


FIG. 10 TWIN-TANDEM ENGINE, HIGH-PRESSURE CYLINDER

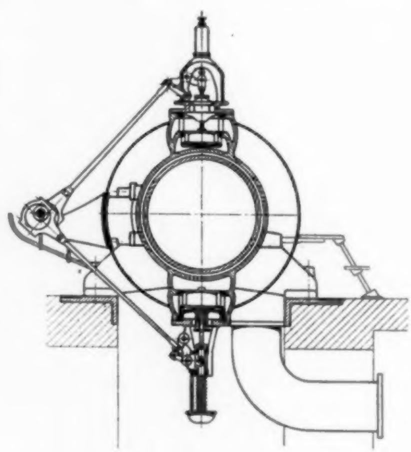


FIG. 11 TWIN-TANDEM ENGINE, LOW-PRESSURE CYLINDER

cannot be clogged by dirt like the nozzle sprayers, do not have to be cleaned so often, and can use impure and pit water. In order to attain a high peripheral velocity, and to produce a complete atomizing of the liquid, the firm Gustav Schlick in Dresden, Germany, has lately constructed a turbine-driven atomizer rotating at 12,000 r.p.m. The atomizer (Fig. 14) *a*, which is regularly supplied by water through the pipe *b*, is bolted on to the shaft *c* and is driven by the turbine *d*, placed in the casing *e*. The shaft runs in the two bearings *f* and *g*, of which the bearing *f* is made movable in order that the shaft might automatically adjust itself to the changes of the position of the center of gravity. The steam is conducted to the turbine through the pipe *i*; the exhaust escapes through *k*; *l* is

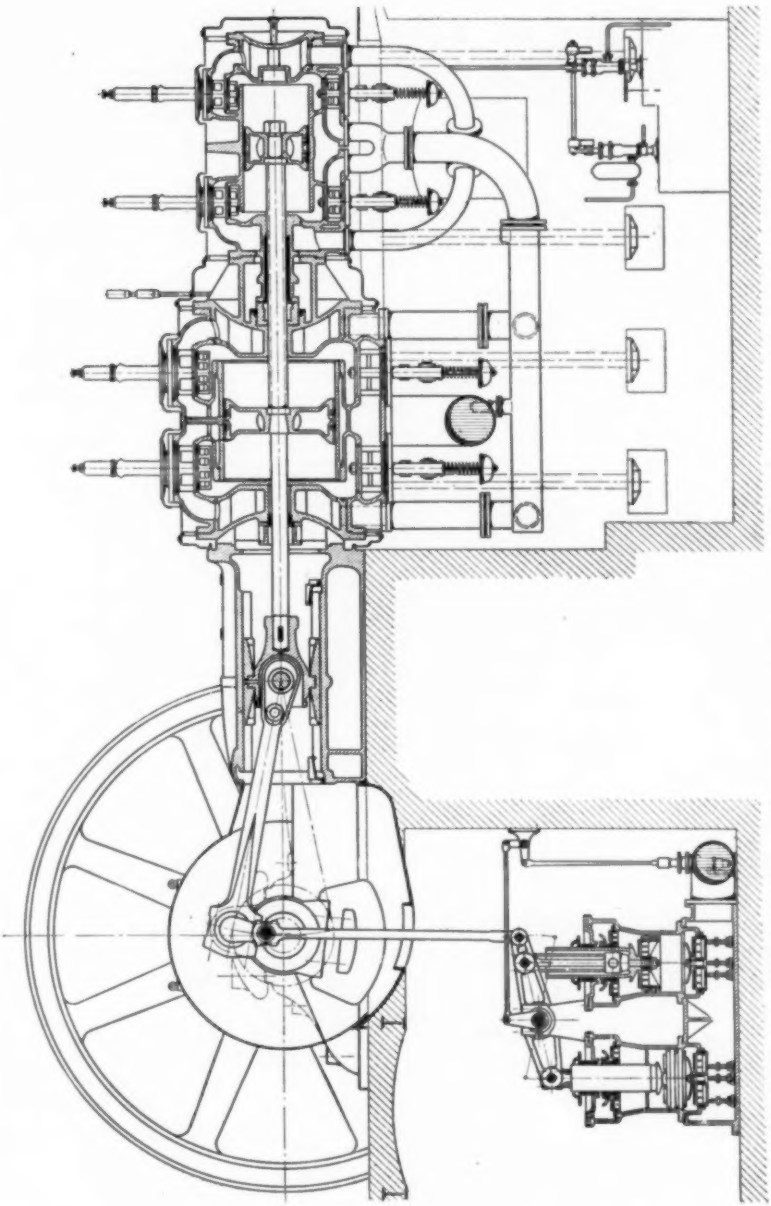


FIG. 12 TWIN-TANDEM ENGINE, LONGITUDINAL SECTION

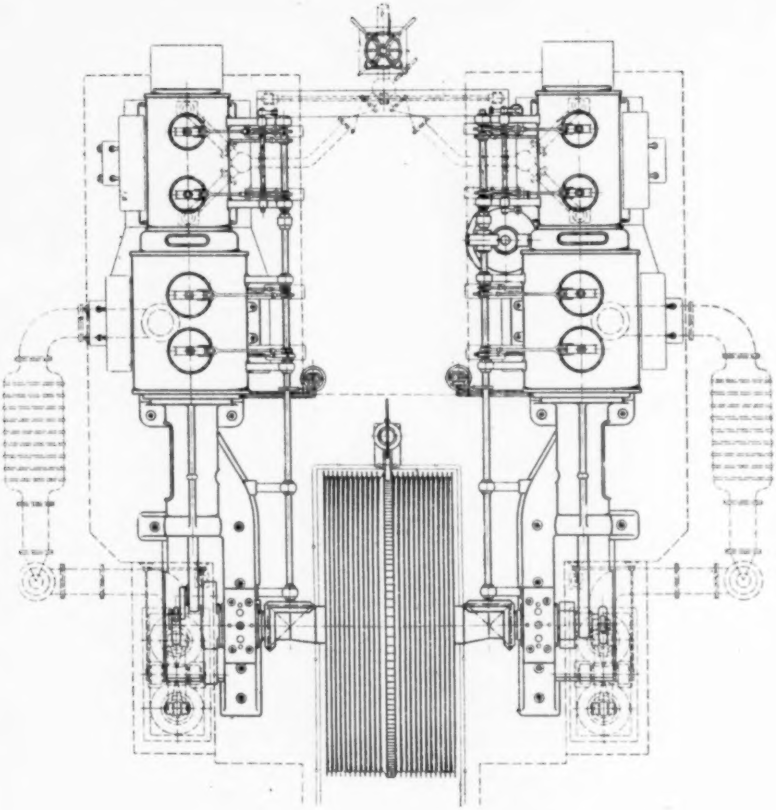


FIG. 13 TWIN-TANDEM ENGINE, PLAN

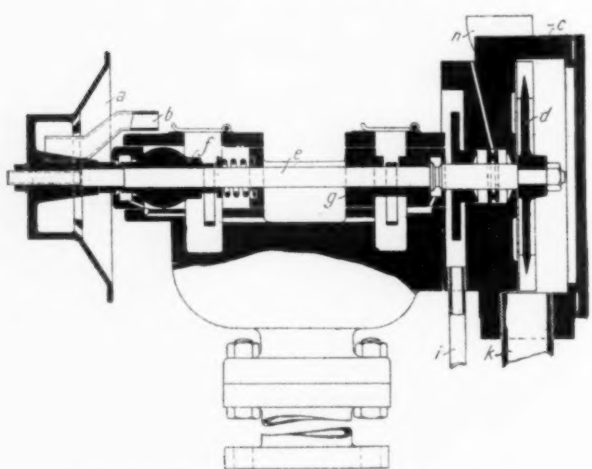


FIG. 14 TURBINE-DRIVEN LIQUID-SPRAYER

a discharge pipe for oil and water of condensation. Compressed air may be used instead of steam. The advantages which are claimed for this type of sprayer are: it can break large amounts of water into finest spray; the amount of water atomized may be regulated by changing the speed of rotation, or the supply of water to the sprayer; the sprayer can be placed in any place and easily set to work, owing to its ability to use compressed air as well as steam.

GENERAL NOTES

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The fourth annual meeting of the American Institute of Chemical Engineers was held at the New Willard Hotel, Washington, D. C., December 20 to 23, 1911 Among the papers were: Advances in Testing Explosives, Clarance Hall; Distribution of Power in Portland Cement Manufacture, R. K. Meade; Problems in the Manufacture of C. P. Acids, J. T. Baker; Combustion of Pulverized Coal, L. S. Hughes; Manufacture of Gelatin, L. Thiele; The Natural Bituminous Rocks of the United States, S. F. Peckham; Symposium on the United States Patent System, E. B. Moore, Edw. T. Fenwick, W. D. Edmonds, R. N. Kenyon; Manufacture and Testing of Carbonic Acid Cylinders, J. C. Minor, Jr.; Some Problems in Chemical Engineering Practice, F. W. Frefichs. The list of excursions was unusually interesting and included a visit to the United States Proving Grounds at Indian Head, Md.; the Patent Office, the Bureau of Standards; the steel plant at Sparrows Point, Baltimore, and the cement plant of the Tidewater Portland Cement Company.

NATIONAL IRRIGATION CONGRESS

The 19th National Irrigation Congress was held in Chicago, Ill., December 5 to 9, 1911. George C. Pardee opened the professional program with an account of the Achievements of the National Irrigation Congress, following which were papers on the Constructive Work of the Reclamation Service, F. H. Newell; Magnitude of Irrigation Interests, R. P. Teele; State Irrigation, W. E. Borah; Government Irrigation in Montana, F. Whiteside; Irrigation by Private Enterprise, R. W. Young; Making the Wilderness Blossom, C. J. Blanchard; Drainage as a Basis for Development, W. L. Park; State Aspect of Drainage, R. V. Fletcher; Reclamation a National Duty, H. C. Leake; One and Indivisible: Forestry, Irrigation, Drainage, Navigation; the Rivers are the Greatest Assets of the Nation when Regulated for all Beneficial Uses, G. H. Maxwell; The Uses of the Great Lakes, Gardner Williams; Pan American Coöperation in Irrigation and Drainage, John Barrett; Irrigation in Western Asia, A. P. Davis; Irrigation and Prosperity, F. G. Newlands; The Present State of Irrigation Development and a Forecast of the Future, S. Fortier; Irrigation in the Humid States, M. B. Williams; Appropriation and Riparian Rights—The California Doctrine, G. H. Hutton; Drainage to Develop Commerce and Industry, A. R. Lawton; Principles Underlying Water Rights, W. J. McGee; Irrigation Finance, N. E. Webster; Relation between Irrigation and Dry Farming, J. A. Widtsoe; Pumping for Irrigation, T. U. Taylor; The Underground Waters of New Mexico, W. E. Holt; Vital Phases of Reclamation Work, E. J. Watson; The Roosevelt Dam, D. B. Heard; Irrigation from Reservoirs, H. G. Clark; National Aspect of Drainage, M. O. Leighton. Dr. Harvey W. Wiley, Chief of Bureau of Chemistry, Department of Agriculture, was also present and addressed the meeting.

AMERICAN CHEMICAL SOCIETY

The annual meeting of the American Chemical Society was held at Washington, D. C., December 27 to 30, 1911, with headquarters at the New Raleigh Hotel. There were numerous papers on the biological, fertilizer, pharmaceutical and organic phases of chemistry, as well as the following addresses: The Teaching of Physical Chemistry, A. A. Noyes; Physical Chemistry in the Introductory Course, W. D. Bancroft; The Introduction of Physical Chemical Conceptions in the Early Stages of the Teaching of General Chemistry, H. C. Jones; Some Applications of Color Photography in the Teaching of Physical Chemistry, J. H. Mathews; The Resins and Their Chemical Relations to the Terpenes, President Frankforter; Privileges and Responsibilities of the Chemical Analyst, H. P. Talbot; Ostwald's Proposed International Institute of Chemistry, A. L. Voge.

PERSONALS

W. N. Dennison has joined the staff of the Gramophone Co., Ltd., of England, as chief engineer and general superintendent of all their European factories, with headquarters at Hayes, Middlesex, England. Mr. Dennison was formerly connected with the Victor Talking Machine Co., Camden, N. J.

Carl F. Dietz, formerly of the firm of Dietz & Keedy, Boston, Mass., has accepted an appointment as plant engineer of the Norton Co., with headquarters at Worcester, Mass. Mr. Dietz has charge of the engineering and construction department covering the company's various plants in this country and abroad.

E. S. Farwell has opened a consulting engineering office in Kansas City, Mo. He was formerly associated with the Yellow Pine Paper Mill Co., Orange, Tex.

Sidney G. Koon, until recently associated with Jones & Laughlin Steel Co., Pittsburgh, Pa., has joined the staff of Walter B. Snow, publicity engineer of Boston, Mass.

V. M. Palmer, formerly superintendent and chief engineer for the Selden Motor Vehicle Co., Rochester, N. Y., and recently chief engineer and manager of the automobile department for the Shelden Axle Co., Wilkes-Barre, Pa., has resigned this position to go with the B. F. Board Motor Truck Co., Alexandria, Va., as factory manager and chief engineer, in which company he has become financially interested.

R. Sanford Riley, of Providence, R. I., who as president of the American Ship Windlass Co. developed the Taylor Stoker, has organized the Sanford Riley Stoker Co., Ltd., and will manufacture a new self-cleaning underfeed stoker.

Manning E. Rupp has accepted a position as inspecting engineer in the Pittsburgh district with the Isthmian Canal Commission. Mr. Rupp was formerly in the engineering department on the canal work, and of late with Stanley G. Flagg & Co., Philadelphia, Pa., as mechanical engineer.

F. Harvey Searight, formerly chief draftsman on the steam design of power stations for the Southern Pacific Co., has become connected with the San Francisco, Cal., office of the Allis-Chalmers Co.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

AERONAUTICAL SOCIETY. Constitution and By-Laws. *New York.*

———Aeronautical Legislation, T. A. Hill.

———Bulletin. Vanadium Steels—Their Relation to Machine Design, July 27, 1911. *New York, 1911.*

———Meetings of November 12, 19, 26, December 9, 16, 30, 1909.

———What It is and What It does. *1910.* Gift of the society.

ALABAMA POLYTECHNIC INSTITUTE. Catalogue of the Officers and Alumni, 1872–1911. *Opelika.*

———Department of Architecture. Bulletin, vol. 6, no. 4, November, 1911. *Auburn, 1911.* Gift of the institute.

ALCOHOLIC FERMENTATION, Arthur Harden. *New York, Longmans, Green & Co., 1911.*

AMERICAN ASSOCIATION OF DEMURRAGE OFFICERS. Proceedings of the 22d Annual Convention. *Niagara Falls, 1911.* Gift of Demurrage Commissioner.

AMERICAN PRACTICE IN CLEANING BLAST FURNACE GAS, Samuel K. Varnes. Journal, Engineers' Society of Pennsylvania, August 1911. *Harrisburg, 1911.* Gift of the author.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Transactions, vol. 32, 1910. *New York, 1911.*

AUTOGENOUS WELDING (Epurite Process). Practical Application of the Oxy-Acetylene Blow Pipe, F. C. Cutler. *New York, 1907.* Reprinted from Cassier's Magazine, September 1907. Gift of Worcester Pressed Steel Company.

AUTOMOBILE TRADE DIRECTORY, October 1911. *New York, 1911.* Gift of Automobile Trade Directory Company.

CHEMISTRY OF THE COAL-TAR DYES, I. W. Fay. *New York, D. Van Nostrand Co., 1911.*

CHICAGO, SANITARY DISTRICT. Report on Sewage Disposal, G. M. Wisner, October 12, 1911. *Chicago, 1911.* Gift of the author.

CONGRESO CIENTIFICO (1° PAN AMERICANO). Ciencias Naturales Antropologicas y Etnologicas, vol. 1. *Santiago de Chile, 1911.*

COST KEEPING FOR MANUFACTURING PLANTS, S. H. Bunnell. *New York, D. Appleton & Co., 1911.* Gift of the author.

A general discussion of the subject, with reproductions of blanks and forms used for various purposes. The chapter on Cost of Labor reviews the various plans suggested by Halsey, Taylor, Gantt and others for rewarding extra efficient workmen. The treatment of the subject throughout is philosophical. The work is certainly one of timely interest.

ELECTRIC CRANE CONSTRUCTION, C. W. Hill. *London, 1911.*

Die Elektrizität im Hause, George Dettmar. Gift of the author.

Engineers' and Mechanics' Pocket-Book, Chas. H. Haswell. ed. 7. *New York, 1851.* Gift of R. B. Bullock.

Drop Forging, Die Sinking and Machine Forming of Steel, J. V. Woodworth. *New York, N. W. Henley Pub. Co., 1911.*

Experiments on the Segregation of Steel Ingots in Its Relation to Plate Specifications, C. L. Huston. Reprinted from American Society for Testing Materials, Proceedings, vol. 6, 1906.

Explanation of the Works of the Tunnel under the Thames from Rotherhithe to Wapping. *London, 1842.* Gift of R. R. Lister.

Factory Accounts, Their Principles and Practice, E. Garcke and J. M. Fells. ed. 6. *London, 1911.*

Framed Structures and Girders, Theory and Practice, E. Marburg. Vol. 1, Stresses. *New York, McGraw-Hill Book Co., 1911.*

Futility of Technical Schools in Connection with Mechanics and Manufacturing or Electrical and Civil Engineering, R. T. Crane. *Chicago, 1911.* Gift of the author.

Die Gasturbine, H. Holzwarth. *1911.* Gift of the author.

Hudson-Fulton Celebration. Catalogues of Scientific Museums and Institutions. *New York, 1910.* Gift of G. F. Kunz.

Inland Waterways. Story of the Atlantic Coastal Project and its Development, J. H. Moore. October 18, 1911. *Richmond, Va., 1911.*

Institution of Mechanical Engineers. Rules and By-Laws.

——List of Members, February 1849. Gift of R. R. Lister.

Manchester Steam Users' Association. Memorandum by Chief Engineer 1910. *Manchester, 1911.* Gift of the association.

Milwaukee Bureau of Economy and Efficiency. Citizens' Free Employment Bureau. Bulletin no. 6. *Milwaukee, 1911.*

——Free Legal Aid. Bulletin no. 7. *Milwaukee, 1911.* Gift of the bureau.

Motor Craft Encyclopedia, B. E. Elliott and P. R. Ward. ed. 2. *Cleveland.*

Museum Coöperation in the Hudson-Fulton Celebration, 1909, G. F. Kunz. Reprinted from Proceedings of American Association of Museums, vol. 4, 1910. Gift of the author.

New York City Department of Docks and Ferries. Report on the Proposed Plan of Operations for Jamaica Bay Improvement. *New York, 1911.* Gift of C. W. Staniford.

New York State Educational Department. Organization and Institutions, October 1911. Handbook 24. *Albany, 1911.*

Oil Analysis, Short Hand-Book, A. H. Gill. ed. 6. *Philadelphia, J. B. Lippincott Co., 1911.*

Papermakers' Pocket Book, James Beveridge. *New York, D. Van Nostrand Co., 1911.*

Pittsburgh Bureau of Water. Annual Report of the Superintendent, 1910. *Pittsburgh, 1911.* Gift of the bureau.

Poor's Manual of Industrials, 1911. *New York, 1911.*

Practical Thermodynamics, F. E. Cardullo. *New York, McGraw-Hill Book Co., 1911.*

PRINCIPLES AND METHODS OF GEOMETRICAL OPTICS ESPECIALLY AS APPLIED TO THE THEORY OF OPTICAL INSTRUMENTS, J. P. C. Southall. *New York, Macmillan Co., 1910.*

PRODUCTION FACTORS IN COST ACCOUNTING AND WORKS MANAGEMENT, A. H. Church. *New York, 1910.*

RAILWAY LIBRARY, 1910, Slason Thompson. *Chicago, 1911.* Gift of the author.

SOLUBILITIES OF INORGANIC AND ORGANIC SUBSTANCES, Atherton Seidell. *New York, D. Van Nostrand Co., 1911.*

STEAM TURBINE DESIGN WITH ESPECIAL REFERENCE TO THE REACTION TYPE, John Morrow. *New York, 1911.*

STRUCTURAL ENGINEERING, Joseph Husband and William Harby. *New York, Longmans, Green & Co., 1911.*

SUBJECT LIST OF WORKS ON CHEMICAL TECHNOLOGY IN THE LIBRARY OF THE PATENT OFFICE. *London, 1911.* Gift of Great Britain Patent Office.

SUBJECT LIST OF WORKS ON PEAT, DESTRUCTIVE DISTILLATION, ARTIFICIAL LIGHTING, MINERAL OILS AND WAXES, GASLIGHTING AND ACETYLENE, IN THE LIBRARY OF THE PATENT OFFICE. *London, 1911.* Gift of Great Britain Patent Office.

TREATISE ON HYDRAULICS, H. J. Hughes and A. T. Safford. *New York, Macmillan Co., 1911.*

A textbook on certain parts of the broad subject of hydraulics, viz., water pressure, stability o simple structures subjected to water and its measurement and the principles of hydraulic motors. The design of motors, hydraulic machinery and power plants is omitted. The treatment of the flow from nozzles through fire hose is particularly clear.

UNIVERSITY OF ROCHESTER. Commencement, 1911. *Rochester, 1911.*

EXCHANGES

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS. Transactions, vol. 4. *New York, 1908.*

BROOKLYN ENGINEERS' CLUB. Proceedings, 1910. *Brooklyn, 1911.*

CANADIAN SOCIETY OF CIVIL ENGINEERS. Index to Transactions, vols. 1–24. *Montreal, 1911.*

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proceedings, vol. 185. *London 1911.*

INSTITUTION OF CIVIL ENGINEERS OF IRELAND. List of Members, June 1911. *Dublin, 1911.*

IRON AND STEEL INSTITUTE. Carnegie Scholarship Memoirs, vol. 3. *London, 1911.*

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS. Transactions, no. 90. *Boston, 1911.*

STEVENS INSTITUTE OF TECHNOLOGY. Annual Catalogue, 1911–1912. *Hoboken, 1911.*

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DEUTSCHEN BUCHDRUCKER BERUFS GENOSSENSCHAFT. Geschafts Bericht, 1910. *Frankfort-on-Main, 1910.*

MANUALS OF SAFETY. ALCOHOLISM IN INDUSTRY: Some European Methods of Prevention. *New York, 1911.* Gift of American Museum of Safety.

MICHIGAN GAS ASSOCIATION. Proceedings of 20th Annual Meeting. *Detroit 1910.* Gift of the association.

New York Society of Architects. Official Year Book, 1911. *New York, 1911.* Gift of the society.

Oklahoma Geological Survey. Preliminary Report on the Road Materials and Road Conditions of Oklahoma. Bulletin no. 8. *Norman, 1911.* Gift of the geological survey.

TRADE CATALOGUES

Diamond Chain & Mfg. Co., *Indianapolis, Ind.* Power chains and sprockets, 96 pp.

Excelsior Drill & Mfg. Co., *Denver, Colo.* Excelsior airometer, 6 pp.

Fawcus Machine Co., *Pittsburgh, Pa.* Worm gearing, 8 pp.

Gesellschaft für Hochdruck-Rohrleitungen, *Berlin.* Power and water mains, 108 pp.

Hess-Bright Mfg. Co., *Philadelphia, Pa.* Heavy truck wheel hubs and various designs of bearings, 9 pp.

Ingersoll-Rand Co., *New York, N. Y.* Rock drill, 16 pp

Lehigh Car, Wheel and Axle Works, *Fullerton, Pa.* Fuller-Lehigh pulverizer mill, 44 pp.

McNabb and Havlin Mfg. Co., *New York, N. Y.* Catalogue of brass and iron fittings for steam, water and gas, 1911, 371 pp.

Sterling Machine Co., *Norwich, Conn.* Mechanical lubricator for general internal lubrication, 8 pp.

Valley City Machine Works, *Grand Rapids, Mich.* Wood-working machinery, 16 pp.

Westinghouse, Church, Kerr & Co., *New York, N. Y.* Central power stations, 49 pp.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for the Bulletin must be in hand before the 12th of the month. The list of men available is made up of members of the Society, and these are on file in the Society office, together with names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0133 Works manager wanted. Old established and well organized company employing 1000 men, manufacturing high-class product, wishes to secure capable works manager of large experience in production of small and accurate mechanisms, such as adding machines, typewriters, firearms, etc. Man under 40 years of age preferred. Applicants are requested to give experience in full; state age, positions occupied, and furnish list of references. To right man, permanent position is assured at liberal salary. Location New York State. Address, care of Am. Soc. M. E.

0134 General manager to take charge, under the president, of production and sales. Foundry employing 500 men, making pipe and fittings, heating boilers and steam fittings, also manufacture of radiators. Location Montreal. Necessary that applicant should have wide experience, both commercial and technical, in manufacture and sale of heating appliances.

0135 Wanted engineer who is familiar with designing hydraulic machinery, especially centrifugal pump. Location Middle West.

0136 Man of all-around engineering knowledge, good organizer and tactful, as head of department of large Ohio concern. Address, care of Am. Soc. M. E.

0137 Wanted by large Eastern manufacturer, designer to handle line of high-grade gate valves up to largest size. State experience, salary expected, etc. Address letters for this position care of the Society.

0138 Expert designer of cameras, preferably one with large experience with film cameras and familiar with patents on same, for firm in Middle West. Salary commensurate with ability to meet the requirements for this position.

0139 Sales engineer with experience in the application of refractory materials for the gas and metallurgical industries, also other branches where refractory fire clay materials are used, principally power plants, sugar refineries, etc. State experience and references. Location New York.

MEN AVAILABLE

332 Teacher of mechanical engineering, at salary of not less than $3000, where there are opportunities for advancement and consulting work; or position

in commercial life as designing engineer, superintendent or works manager with firm manufacturing any variety of heavy machinery, steam or gas engines or machine tools preferred.

333 Member, desires to represent New York firm in Boston and New England states. Already established. Sales engineer for any line of machinery on commission basis. Extensive experience.

334 Junior, experienced in special tool design and in charge of men; shop, pipe, plumbing and sheet metal work, steel foundry, power plant design and construction; would like position promising advancement.

335 Engineer of proven executive ability, wide experience in manufacturing heavy and light machinery, including iron and brass foundry practice; desires to become connected with or represent machinery manufacturer. At present officer of company manufacturing heavy machinery.

336 Engineer of varied experience, at present employed, desires change. Prefers design, construction and operation of cement mills; would consider general engineering. Thorough, reliable, systematic, and good organizer. Salary $2500.

337 Junior, age 28, college training, five years' experience as shop foreman, sales engineer, and contractor. At present with large locomotive works; desires position as purchasing agent or in purchasing department.

338 Mechanical-electrical engineer, 11 years' broad experience, government, railroad and factory connections. Competent as contractors' or engineer's assistant and as industrial inspector and plant engineer.

339 Junior, age 28, technical graduate, seven years' experience with contractors and engineers as draftsman, estimator, assistant to engineer in charge, selling, heating and ventilating, design of railroad cars and contractors' equipment; would like to make change first of year for commercial position calling for engineering experience. At present engaged with contracting company.

340 Graduate mechanical engineer, experienced in design and sale of heating, ventilating and drying apparatus. Specialist in mechanical draft and general boiler room practice. Six years in present position as sales engineer with manufacturer of above apparatus.

341 Member with wide experience as superintendent, modern machine shop practice, expert on tools and methods for increasing production and reducing costs.

342 Student member; Cornell graduate, practical experience with water-tube boiler company; will consider any proposition where there is good opportunity for advancement.

343 Junior, 30 years of age, 12 years' experience designing and building automatic machinery, variable speed devices and foundry equipment, desires position as plant engineer or assistant superintendent. Experienced in handling large production of duplicate parts in foundry and shop. At present employed in similar capacity.

344 Graduate mechanical engineer, nine years' experience; in responsible charge of six power plants, desires position in power plant or manufacturing work in the vicinity of New York.

345 Junior, at present employed as draftsman and designer by hydro-electric company, would like to make connection as testing engineer in large manufacturing plant or as manager or assistant manager of power plant. Technical education and training.

346 Experienced designer of special machinery, tools and fixtures for manufacturing purposes; expert in manufacturing equipment; desires responsible position in the Middle West.

347 Young mechanical engineer, Cornell graduate, desires position as assistant to manager with a view to working into sales or engineering department. Location immaterial.

348 Mechanical engineer desires position as manager or superintendent of small growing factory; 32 years of age; married; technical graduate. Four years' practical experience in machine shop and drafting room; four years devising and installing complete cost, shop and production systems; three years as factory executive in responsible charge. Experienced in laying out and installing industrial plants and electric installations.

349 Mechanical and electrical engineer, Cornell graduate, ten years' experience, in steam and hydraulic power-plant construction, gas work, building construction, including reinforced concrete, factory superintendence and maintenance, desires position with consulting or contracting firm or as executive engineer in manufacturing concern.

CHANGES IN MEMBERSHIP

CHANGES IN ADDRESS

ANGSTRÖM, Carl (1883), Cons. Engr., Skepparegatan 5, Stockholm, Sweden.

ANGUS, Robert (1891), Cons. Engr., 705 Confederation Life Bldg., Toronto, and 514 William St., London, Ont., Canada.

BAILEY, Frederic W. (Junior, 1901), 527 Linwood Ave., Buffalo, and Skaneateles, N. Y.

BANKS, Thomas Dent (Junior, 1910), Asst. Engr., Dept. Pub. Service, and *for mail*, 163 W. 9th Ave., Columbus, O.

BARSTOW, Francis Loring (1905; 1911), Engr., Leitch & Barstow, Engrs., 172 Main St., and 691 State St., Springfield, Mass.

BENTON, George H. (1908), Pres. and Mgr., Benton Valve Co., 140 Liberty St., New York, N. Y., and *for mail*, Metuchen, N. J.

BERRY, Edgar H. (1905; 1907), Hotel Euclid, Cleveland, O.

BRADY, Joseph Benjamin (Junior, 1910), Joseph T. Ryerson & Sons, 16th and Rockwell Sts., and 1806 S. Homan Ave., Chicago, Ill.

CARLSSON, Carl A. V. (1905), Mech. Engr., 3921 Eighth St., N. W., Washington D. C.

CARPENTER, Alfonso H. (Associate, 1895), V. P., Acme Mchy. Co., Cleveland, O., and *for mail*, Westlake Hotel, Los Angeles, Cal.

CATLIN, William Lyle (Junior, 1906), Supt., The Wheland Co., and 608 Kirby Ave., Chattanooga, Tenn.

COWGILL, Paul Everett (Junior, 1910), The Weinman Pump Mfg. Co., and 1775 Franklin Park, S., Columbus, O.

DENNISON, Wilburn Norris (1905), Ch. Engr. and Genl. Supt., The Gramophone Co., Ltd., English and Continental Wks., Hayes, Middlesex, England.

DIETZ, Carl F. (1903; 1910), Plant's Engr., Norton Co., Worcester, and *for mail*, 214 Lynn Fells Parkway, Melrose, Mass.

DUNKIN, William Van (1909), Instr. Mch. Design, Univ. of Ill., and *for mail*, University Sta., Urbana, Ill.

FALKENAU, Arthur (1886), Industrial and Cons. Engr., 165 Broadway, and *for mail*, 911 Park Ave., New York, N. Y.

FRANKS, Fredk. B. (1904), Mgr. Operating and Constr. Cement Plant, Bath Portland Cement Co., Bath, Pa.

GRIFFITHS, Leonard L. (1905; 1908), Pres. and Mgr., The L. L. Griffiths Engrg. Co., Cons. Civ. Mech. and Elec. Engrg., 708 Trust Bldg., Dallas, Tex.

HEAD, Francis (1906), Engr. of Constr., The Sao Paulo Tramway, Light & Power Co., Ltd. Sao Paulo, Brazil, S. A.

HOPPES, John J. (1890), Pres., Hoppes Mfg. Co., and Trump Mfg. Co., and *for mail*, 1330 E. High St., Springfield, O.

HUSSEY, Charles Ward (Junior, 1908), Asst. Engr. Mechanigraph Dept.,

Topping Bros., 122 Chambers St., New York, and *for mail*, 33 St. Andrews Pl., Yonkers, N. Y.

JACKSON, Charles J. (1905), Secy. and Genl. Mgr., Easton Tool & Mch. Co., 39 N. Sitgreaves St., Easton, Pa.

LOGAN, John W. (1894; 1899; 1904), Mgr. Steel Wks. Dept., Alan Wood Iron & Steel Co., Conshohocken, Pa.

McDEWELL, Horatio S. (Junior, 1908), Gas Eng. Erecting Engr., Allis-Chalmers Co., Milwaukee, Wis., and *for mail*, The Adamston, 251 W. 89th St., New York, N. Y.

MacGILL, Charles Frederick (1896), Twin City Lines, 406 N. Snelling Ave., and *for mail*, 1489 W. Minnehaha St., St. Paul, Minn.

MERRILL, Albert S. (Junior, 1903), 334 Bushkill St., Easton, Pa.

MILLER, John S. (1900; 1907), Natomas Consltd. of Cal., Natoma, Cal.

MOORE, Harold T. (Associate, 1907), Cruse-Kemper Co., Ambler, and *for mail*, 2031 Spruce St., Philadelphia, Pa.

MUHLFELD John E. (1908), V. P. and Genl. Mgr., Kansas City So. Ry., and *for mail*, 3712 Washington St., Kansas City, Mo.

RICHTER, Ernst (1890), Ch. Draftsman, The G. A. Gray Co., Cincinnati, and *for mail*, Lafayette Circle, Clifton, Cincinnati, O.

RYAN, Harris J. (1896), Prof. Elec. Engrg., Leland Stanford Jr. Univ., Stanford Univ. P. O., and *for mail*, La Jolla, Cal.

SALMON, Frederick W. (1900; 1904), Civ. and Mech. Engr., Murray Iron Wks., Burlington, Ia., and *for mail*, Owen Sound, Ont., Canada.

SAWFORD, Frank (1909), Canadian Collieries, Ltd., Victoria, B. C., Canada.

SCHAUM, Otto W. (1894), Mfr. of Textile Mchy., Glenwood Ave. and 2d St., and *for mail*, 1508 Allegheny Ave., Philadelphia, Pa.

SMART, Richard Addison (1894; 1900; 1906), Canadian Home Land Co., Ltd., Bank of Hamilton Chambers, Hamilton, Ont., Canada.

TIFFT, Robert Hull (Junor, 1910), Westinghouse, Church Kerr & Co., 10 Bridge St, New York, N. Y.

NEW MEMBERS

ALLEN, John L. (1911), V. P. and Genl. Mgr., Hastings Motor Shaft Co., Hastings, Mich.

BACHMAN, Robert A. (1911), Mgr., Edison Storage Battery Co., Orange, and *for mail*, West Orange, N. J.

BARR William Henry (Associate, 1911), Genl. Mgr., Lumen Bearing Co., and 1155 Sycamore St, Buffalo, N. Y.

BATT, William Lorraine (Junior, 1911), Ry. Engr., The Hess-Bright Mfg. Co., 21st and Fairmount Ave., Philadelphia, Pa.

BECK, Charles Edgar (Junior, 1911), Sales Engr., De La Vergne Mch. Co., 1504 Fisher Bldg., and *for mail*, 4855 Winthrop Ave., Chicago, Ill.

BRAKEMAN, Roy Edgar (1911), Asst. Ch. Engr. Steel Wks. and Blast Furnace Dept., Tenn. Coal, Iron & R. R. C., and *for mail*, Box 36, South Highland, Sta., Birmingham, Ala.

BRENNAN, James (Junior, 1911), Ch. Engr., Crucible Steel Co. of Am., 2014 Oliver Bldg., and *for mail*, Beechwood Blvd , E. D., Pittsburgh, Pa.

BURLEIGH, William Henry (Junior, 1911), 1418 Arlington Ave., Davenport, Ia.

BURNS, Homer S. (1911), Field Supt., Westinghouse Church Kerr & Co., and *for mail*, Box 248, Sta. B. Hamilton, Ont., Canada.

CAIRNS, William (1911), Genl. Mgr., The Parish & Bingham Co., and *for mail,* 1421 E. 85th St., Cleveland, O.

CARTER, Edgar Robert, Jr. (Junior, 1911), Mech. Engr., Evans, Almirall & Co., 316 Confederation Life Bldg., Toronto, Canada, and Tompkinsville, N. Y.

CASSIDY, Andrew George (1911), M. M,. Waltham Watch Co., Waltham, Mass.

CHALMERS, John Brown (Junior, 1911), Instr., Pratt Inst., and *for mail,* 244 DeKalb Ave., Brooklyn, N. Y.

COOK, Thomas R. (1911), Asst. Engr. M. P., Office Genl. Supt. M. P., Pa. Lines West, and *for mail,* 205 N. Negley Ave., Pittsburgh, Pa.

COOK, William Pierson, Jr. (Junior, 1911), Engr., The Griscom-Spencer Co., 90 West St., New York, and *for mail,* 1111 Dean St., Brooklyn, N. Y.

CRAIGLOW, Harry H. (Junior, 1911), Plant Engr., The Buckeye Steel Castings Co., and *for mail,* 80 Wood Ave., Columbus, O.

CROCKER, Arthur George (Junior, 1911), Leading Draftsman, Chicago & Northwestern Ry., and *for mail,* 344 N. Howard Ave., Chicago, Ill.

DENT, John Adlum (Junior, 1911), Instr. Mech. Engrg., Univ. of Ill., Urbana, Ill.

DOW, Benjamin Warren (Junior, 1911), Asst. Engr. Constr. Wk., Stone & Webster Engrg. Corp., 147 Milk St., Boston, and *for mail,* 7 Standish St., Dorchester, Mass.

DOW, Charles Eugene Willey (1911), Selling Agt. and Mech. Engr., Am. Moistening Co., Boston, and *for mail,* 7 Standish St., Dorchester, Mass.

DOWD, Wyllys E., Jr. (1911), Philadelphia Mgr., Power Spec. Co., Land Title Bldg., Philadelphia, Pa., and University Club, New York, N. Y.

DUNLAP, George W. (1911), Supt. Power Stations, Worcester Consltd. St. Ry. Co., and *for mail,* 107 Main St., Worcester, Mass.

DUSOSSOIT, Octave (Associate, 1911), Res. Agt., Hohmann & Maurer Mfg. Co., Boston, and *for mail,* 156 Mason Terrace, Brookline, Mass.

EDWARDS, William B. (1911), Cons. Engr., The United Shoe Machy. Co., and *for mail,* 17 E. 9th St., Derby, Conn.

ERWIN, William W. (1910), N. Y. Edison Co., 55 Duane St., New York, N. Y.

FOGARTY, William James (1911), Mech. Engr., Barney & Smith Car Co., and *for mail,* 74 Fountain Ave., Dayton, O.

FULTON, Arthur Oram (Junior, 1911), Sales Engr., Wheelock, Lovejoy & Co., Boston, and *for mail,* 21 Harrington St., Newtonville, Mass.

GOLDSMITH, Clarence (1911), Asst. Engr. in Charge High Pressure Fire Service, Pub. Wks. Dept., City of Boston, 1 City Sq., Charleston, Mass.

GUNN, Charles M. (1911), Pres. and Mgr., Columbia Steel Co., 503 Market St., San Francisco, Cal.

HARDING, James Morgan (Junior, 1911), Sales Engr., Dodge Mfg. Co., 815 Arch St., Philadelphia, Pa.

HARRIS, Harry E. (1911), 24 Orchard St., Greenfield, Mass.

HINRICHS, Frederic William, Jr. (1911), Asst. Prof. Applied Mech., Univ. of Rochester, and *for mail,* 216 Oxford St., Rochester ,N. Y.

HOFFMANN, Simon (1911), First V. P., Loco. Superheater Co., 30 Church St., New York, N. Y.

HUNTER, Charles Welsh (Junior, 1911), Gas Engr., Stone & Webster Engrg. Corp., 147 Milk St., Boston, Mass.

JACKSON, Charles Arthur (1911), Mech. and Hyd. Engr., The Pelton Water Wheel Co., 90 West St., New York, N. Y.

KAUFFMANN, Frederick F. (1911), Asst. to Ch. Engr., N. Y. Shipbuilding Co., and *for mail*, 909 Pine St., Camden, N. J.

KING, Charles Arthur (Junior, 1911), Asst. Cons. Engr. to Henry C. Meyer, Jr., 1 Madison Ave., New York, N. Y., and *for mail*, 911 Watchung Ave., Plainfield, N. J.

KONSTANKEWICZ, Michael John (Junior, 1911), Asst. Mech. Engr., The Strathmore Paper Co., Mittineague, Mass.

KOPLIN, Robert Deemer (Junior, 1911), Y. M. C. A. Bldg., Wilkes-Barre, Pa.

KORNFELD, Alfred Ephraim (Associate, 1911), Mgr., Engineering News Publishing Co., 505 Pearl St., New York, N. Y.

LAUGHLIN, Alex, Jr. (Junior, 1911), Engr., Alex. Laughlin & Co., Lewis Bldg., Pittsburgh, Pa.

LESSER, W. H. (Junior, 1911), Mech. Engr., Philadelphia & Reading Coal & Iron Co., and *for mail*, 604 N. 3d St., Pottsville, Pa.

LINDSTROM, J. A. (1911), Struc. Engr., Genl. Chem. Co., 25 Broad St., New York, and *for mail*, 97A Seventh Ave., Brooklyn, N. Y.

MARTIN, George W. (1911), V. P. and Genl. Mgr., The N. Y. Service Co., 320 Broadway, New York, N. Y.

McMURTRY, Alden Lothrop (1911), 1737 Broadway, New York, N. Y.

MERRILL, Joseph J. (1911), Ch. Engr., Corn Products Refining Co., 29 E. Madison St., and *for mail*, 229 S. Central Park Ave., Chicago, Ill.

MURPHY, William T. (Junior, 1911), Mgr., Stand. Mchy. Co., 7 Beverly St., Providence, R. I.

NESBIT, Joseph Newton Gray (1911), Prof. Exper. Engr., Ga. Sch. of Tech. Atlanta, Ga.

OHLSON, Olof (1911), Mech. Supt., Waltham Watch Co., Waltham, and *for mail*, 472 Crafts St., West Newton, Mass.

PEARSON, Albert L. (1911), Elec. Engr., Lockwood, Greene & Co., 93 Federal St., Boston, Mass.

PETERSON, John William (1911), Pres. and Mgr., Peterson Engrg. Co., 50 Church St., New York, N. Y.

PIERPONT, Robert (1911), Factory Mgr. and Engr., Olds Motor Wks., and *for mail*, 222 Genesee St., Lansing, Mich.

PUGSLEY, Edwin (Junior, 1911), Spec. Apprentice, Winchester Repeating Arms Co., and *for mail*, 110 Whitney Ave., New Haven, Conn.

QUICK, Ray Lewis (Junior, 1911), Pratt & Whitney Co., and *for mail*, 12 Babcock St., Hartford, Conn.

QUIRKE, Edward D. (1911), Designer and Checker, Natl. Tube Co., and *for mail*, 119 W. South St., Kewanee, Ill.

RANDALL, John Arthur (Junior, 1911), Instr. Mech. and Heat, Pratt Inst., Brooklyn, N. Y.

REGAN, Joseph Charles (1911), Supt., Yale & Towne Mfg. Co., and 370 Summer St., Stamford, Conn.

RICHARDSON, Charles Germane (1911), Sales Engr. Meter Dept., Builders Iron Fdy., and *for mail*, 65 Comstock Ave., Providence, R. I.

ROWNTREE, Bernard (Associate, 1911), East. Engr., Burdett-Rowntree Mfg. Co., Rm. 1883, 50 Church St., New York, N. Y.

SACHS, Joseph (1911), V. P. and Genl. Mgr., The Sachs Laboratories, Inc., 103-105 Allyn St., Hartford, Conn.

SAEGMULLER, George Nicholas (1911), Mech. Engr., Mfr., Bausch & Lomb Optical Co., and *for mail*, 1100 St. Paul St., Rochester, N. Y.

SAYRE, William Heysham (1911), Pres., Am. Abrasive Metals Co., Mgr., Internatl. Contr. Co., 50 Church St., New York, N. Y.

SCHAEFER, Frederick Rullman (Junior, 1911), Sales Engr., Taylor Iron & Steel Co., 100 Broadway, New York, N. Y.

SCHALLER, Alwin Louis (Junior, 1911), Ch. Draftsman, McEwen Bros., and *for mail*, 30 Jefferson St., Wellsville, N. Y.

SMITH, William (1911), M. M. Eliza Furnaces, Jones & Laughlin Steel Co., and *for mail*, 3233 Park View Ave., Pittsburgh, Pa.

SMITH, William H. (1911), Genl. Mgr. and Secy., John R. Keim Mills, Inc., and *for mail*, 52 W. Oakwood Pl., Buffalo, N. Y.

SNYDER, William R. (Junior, 1911), Supt., Fulton Bag & Cotton Mills, 236 Spring St., New York, N. Y.

SPENCER, C. C. (1911), Supt., Westinghouse Church Kerr & Co., 10 Bridge St., New York, N. Y.

STANFORD, J. Verne (1911), Asst. Prof. Mech. Engrg., Univ. of Pa., and *for mail*, 5121 Chestnut St., Philadelphia, Pa.

STRAUB, Albert A. (Junior, 1911) Asst. Ch. Engr. of Power Stations, Pittsburgh Rys. Co., and *for mail*, 417 Hastings St., Pittsburgh, Pa.

STUBBLEBINE, Winfred Albertis (1911), Engr., The Lehigh Fdy. Co., Fullerton, Pa.

SVENSEN, Carl Lars (Junior, 1911), Instr. Mech. Engrg., Tufts College, Tufts College P. O., Mass.

THROCKMORTON, George Kenneth (Junior, 1911), Merchandise Examiner, Sears, Roebuck & Co., and *for mail*, 3830 W. Adams St., Chicago, Ill.

THURMAN, Charles Ross (1911), Ch. Engr., Elec. Renovator Mfg. Co., and *for mail*, 431 Amberson Ave., Pittsburgh, Pa.

TODD, James (1911), Pres. and Ch. Engr., The Sterling Varnish Co., Pittsburgh, Pa.

UTLEY, Joseph Cole (Junior, 1911), Steam and Hyd. Engrg. Dept., Natl. Tube Co., and *for mail*, P. O. Box 358, McKeesport, Pa.

VOSBURY, W. DeWitt (1911), Mech. Engr., P. O. Bldg., Darby, and *for mail*, Colwyn, Pa.

WACHS, Theodore (Junior), 1911, Asst. Production Engr., Sears, Roebuck & Co., and *for mail*, 2725 Pine Grove Ave., Chicago, Ill.

WALTON, Albert (Associate, 1911), Shop Systematizer and Expt. Accountant, M. Rumely Co., La Porte, Ind.

WARDER, Walter J., Jr. (1911), Crocker Wheeler Co., Ampere, N. J.

WEBSTER, William Ralph (1911), Designer and Squad Foreman of Checkers, Cambria Steel Co., and *for mail*, 542 Horner St., Johnstown, Pa.

WILSON, Chester Worcester (Junior, 1911), 25 Emmons Pl., New Britain, Conn

PROMOTIONS

BOUGHTON, Judson H. (1903; 1911), Pres., Natl. Light & Power Co., Pierce Bldg., and 6343 Berlin Ave., St., Louis, Mo.

CASTLE, Samuel Northrup (1909; 1911), Genl. Elec. Co., 30 Church St., New York, N. Y.

DREYFUS, Edwin D. (1905; 1911), Commer. Engr., The Westinghouse Mch. Co., East Pittsburgh, and 422 Hampton Ave., Wilkinsburg, Pa.
HOGLE, Milton, W. (1901; 1906; 1911), Asst. Wks. Mgr., The T. H. Symington Co., and *for mail*, 128 Linden St., Rochester, N. Y.
McMULLEN, Vincent E. (1907; 1911), Genl. Foreman Gas Eng. Dept., Fairbanks, Morse Mfg. Co., and *for mail*, 1251 Josephine Ave., Beloit, Wis.
PHETTEPLACE, Thurston M. (1904; 1911), Asst. Prof. Mech. Engrg., Brown Univ., and *for mail*, 1596 Broad St., Providence, R. I.

DEATHS

DAVIS, Thomas B., November 3, 1911.
FERRIER, Joseph J., October 30, 1911.
HASKINS, Caryl D., November 18, 1911.
JOHNSON, Warren S., December 5, 1911.
MIX, Edgar W., November 12, 1911.
SALTER, Thomas Fitch, October 25, 1911.

COMING MEETINGS

January–February

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading, and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
December 27–January 3, annual meeting, Washington, D. C. Secy., L. O. Howard, Smithsonian Institution.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
January 12, monthly meeting, 29 West 39th St., New York. Secy., F. L. Hutchinson.

AMERICAN SOCIETY OF CIVIL ENGINEERS
January 17–18, annual meeting, New York. Secy., Chas. Warren Hunt, 220 West 57th St.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS
January 9, annual meeting, New York. Secy., J. R. Wemlinger, 13 Park Row.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
January 23–25, annual meeting, 29 West 39th St., New York. Secy., W. W. Macon.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Monthly Meetings: New York, January 9; Boston, January 15; San Francisco, January 15. Secy., Calvin W. Rice, 29 West 39th St., New York.

CEMENT PRODUCTS EXHIBIT
January 29-February 3, exhibit, New York. Office, 72 West Adams St., Chicago, Ill.

ENGINEERS SOCIETY OF WESTERN PENNSYLVANIA
January 16, annual meeting, Pittsburgh, Pa. Secy., Elmer K. Hiles, 2511 Oliver Bldg.

SOCIETY OF AUTOMOBILE ENGINEERS
January 18–20, annual meeting, New York. Secy., Coker F. Clarkson, 1451 Broadway.

NEW ENGLAND WATERWORKS ASSOCIATION
January 10, annual meeting, Hotel Brunswick, Boston, Mass. Secy., Williard Kent, Narragansett Pier, R. I.

WOOD PRESERVERS' ASSOCIATION
January 16–18, annual meeting, Chicago, Ill. Secy., F. J. Angier, Mount Royal Station, Baltimore, Md.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
January			
4	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
9	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
11	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
12	American Institute of Electrical Engineers	F. L. Hutchinson (Acting Secy.)	8.00 p.m.
16	New York Telephone Society	T. H. Lawrence	8.15 p.m.
19	New York Railroad Club	H. D. Vought	8.15 p.m.
23–25	American Society of Heating and Ventilating Engineers	W. W. Macon	All day
24	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
February			
1	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
8	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
9	American Institute of Electrical Engineers	F. L. Hutchinson (Acting Secy.)	8.15 p.m.
13	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
16	New York Railroad Club	H. D. Vought	8.15 p.m.
28	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.

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Society History
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Reception to Delegates of International Congress of Navigation

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Meetings of the Society in Boston

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Meetings of the Society in New York

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Meetings of the Society in San Francisco

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Meetings of the Society in Philadelphia

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Meetings of the Society in New Haven

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OFFICERS OF STUDENT BRANCHES

INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	PRESIDENT	CORRESPONDING SECRETARY
Stevens Inst. of Tech.	Dec. 4, 1908	Alex.C.Humphreys	A. E. Bauhan	A. D. Karr
Cornell University	Dec. 4, 1908	R. C. Carpenter	F. E. Yoakum	D. S. Wegg, Jr.
Armour Inst. of Tech.	Mar. 9, 1909	G. F. Gebhardt	A. J. Beerbaum	P. L. Keachie
LelandStanfordJr.Univ.	Mar. 9, 1909	W. F. Durand	C. H. Shattuck	C. W. Scholefield
Brooklyn Poly. Inst.	Mar. 9, 1909	W. D. Ennis	A. L. Palmer	R. C. Ennis
Purdue University	Mar. 9, 1909	L. V. Ludy	L. Jones	H. E. Sproull
University of Kansas	Mar. 9, 1909	P. F. Walker	V. H. Hilford	L. L. Browne
New York University	Nov. 9, 1909	C. E. Houghton	Harry Anderson	Andrew Hamilton
Univ. of Illinois	Nov. 9, 1909	W. F. M. Goss	F. J. Schlink	E. J. Hasselquist
Penna. State College	Nov. 9, 1909	J. P. Jackson	J. A. Kinney	H. S. Rodgers
Columbia University	Nov. 9, 1909	Chas. E. Lucke	N.E.Hendrickson	W. E. Ruprecht
Mass. Inst. of Tech.	Nov. 9, 1909	E. F. Miller	J. A. Noyes	R. M. Ferry
Univ. of Cincinnati	Nov. 9, 1909	J. T. Faig	C. J. Malone	J. H. Schneider
Univ. of Wisconsin	Nov. 9, 1909	H. J. B.Thorkelson	F. B. Sheriff	L. F. Garlock
Univ. of Missouri	Dec. 7, 1909	H. Wade Hibbard	G. D. Mitchell	P. A. Tanner
Univ. of Nebraska	Dec. 7, 1909	C. R. Richards	W. O. Forman	C. A. Bennett
Univ. of Maine	Feb. 8, 1910	Arthur C. Jewett	A. H. Blaisdell	W. B. Emerson
Univ. of Arkansas	Apr.12, 1910	B. N. Wilson	W. Q. Williams	W. B. Gardner
Yale University	Oct. 11,1910	L. P. Breckenridge	F. M. Jones	W. St. C. Childs
Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	W. D. Small	A. E. Moore
State Univ. of Ky.	Jan.10, 1911	F. P. Anderson	J. W. Cary	J. T. Lowe
Ohio State University	Jan.10, 1911	E. A. Hitchcock	H. T. Lang	W. J. Assel
Washington University	Mar.10, 1911		E. Daugherty	F. E. Glasgow
Lehigh University	June 2, 1911			Nevin H. Guth